Volume 7 February 1961 No. 2



# Canadian Aeronautical Journal



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# BULLETIN:

## Exclusive Shell gelling agent that can't melt ever makes possible a remarkable grease that may well solve every bearing lubrication problem in your plant

**Many manufacturers who change to Shell's multi-purpose Darina Grease find they can more than double the length of periods between lubrications. This reduces maintenance costs and increases production rates.**

**Read how an exclusive Shell gelling agent enables Darina Grease to work efficiently at temperatures as low as −30F°. and as high as 400°F. And how Darina Grease lubricates thoroughly under conditions wet enough to emulsify soap-base greases.**

THE SECRET of Darina Grease* is an exclusive Shell gelling agent that is extracted from a rare ore discovered in the Mojave Desert.

This extraordinary gelling agent does the job that soap does in ordinary greases.

Only it does it far better. The trouble with soap-base greases is that they melt at high temperatures. This permits them to run out of your bearings.

### Thick and buttery at 400° F.

The gelling agent in Darina Grease has no melting point. So Darina Grease stays thick and buttery at operating temperatures up to 400° F.

Darina Grease is also effective at *low* temperatures. It won't solidify even at −30° F. You can pump it into ice-cold bearings.

NOTE: *One member of the Darina family, Microgel Grease Lowtherm, can actually be pumped into bearings at −60° F.*

Here are some of the other advantages of this outstanding multi-purpose grease:

**Resists washout.** Soap-base greases tend to emulsify when they get wet, and then wash out of bearings. Darina Grease will lubricate even under extremely wet conditions.

**Resists corrosive liquors.** This makes it ideal for paper mills.

**Forms an excellent seal.** It seals bearings against contamination from outside.

**Protects bearings against rust.** A "particle water proofant," developed by Shell research, enables Darina Grease to do an even better job of rust-prevention than other non-soap greases do.

**Extraordinarily stable.** It lasts an exceptionally long time.

### "One plant, one grease"

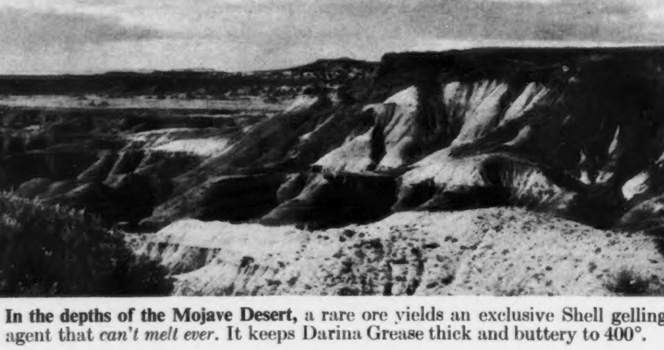
The remarkable properties of Darina Grease have led Shell engineers to develop a new approach to lubrication problems. They call it the "one plant, one grease" concept.

This idea is exactly what it sounds like. You use Darina Grease exclusively throughout your plant. This simplifies your inventory, saves space and money.

Another money saver: Darina Grease can dramatically lengthen periods between lubrications. *Doubling* the period is common. Cases have been reported where Darina Grease stretched a lubrication cycle from twice a day to once every two weeks—in the face of steam and high temperatures.

### Talk to the man from Shell

Why not get in touch with your Shell representative? He'll be able to give you any technical advice you may need. And don't be surprised if he saves you a good deal of money.



**In the depths of the Mojave Desert,** a rare ore yields an exclusive Shell gelling agent that *can't melt ever*. It keeps Darina Grease thick and buttery to 400°.

SHELL

**A BULLETIN FROM SHELL OIL COMPANY OF CANADA, LIMITED**

*Reg'd. T.M.*

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**Dr. G. N. Patterson**

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# CF-104 PRECISION CONTRACTS TO JARRY HYDRAULICS

Because of a substantial reputation for the ability to produce highly sophisticated equipment, Jarry Hydraulics Limited has been awarded contracts for the Canadair-built CF-104 which will take full advantage of the Company's precision manufacturing skills. These call for Jarry to supply:

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# TCA'S VICKERS VANGUARD


**The new 96 passenger Vickers Vanguard, powered by four Rolls-Royce Tyne XI turboprop engines, has recently been introduced into service on TCA's short-to-medium length routes.**

# EDITORIAL

## MEETINGS

In his dinner address to the Joint IAS/CAI Meeting last October, Mr. F. R. Thurston, Director of the National Aeronautical Establishment, shook the massive and traditional pillars of society activities and found some of them a little unsteady with age. In particular, he suggested that stereotyped meetings with their formal presentation of papers were inefficient and expensive ways of exchanging information in these days of mass communication. For some time this problem has been the subject of much discussion in and out of the councils of many societies. It is worth thinking about.

Since it was founded, the Institute has adopted a pattern of meetings based on long established practices developed by technical societies and institutions throughout the world. Our meetings have normally comprised four or more half-day sessions, at each of which two or three papers have been presented. There has been opportunity for discussion after each paper but, though the discussion has often shown a good deal of academic interest in the subject of the paper, it has seldom been argumentative. It has usually taken the form of a few polite questions and even politer answers. It has rarely displayed any controversy or disagreement. True, the discussion has sometimes been revived in a more lively manner and sometimes at great length and heat in small and informal sessions afterwards, but these uninhibited skirmishes have benefited only a few. When preprints of the paper have been available – and the practice has been discontinued of recent years – they have not attracted much attention before the sessions, but have been picked up after the sessions by those who found the papers interesting and wished to study them at more leisure. This in itself is a point of some significance; the oral presentation has become little more than an advertisement of the written.

In principle the idea of a meeting is sound enough but in practice, over the years, technical meetings have lost some of their punch. They have become formalized and too often papers are presented for the sole purpose of making up a programme. This is a pity, for the spirit of the Areopagus will always be a powerful influence in the advancement of knowledge and it must not be allowed to stagnate in backwaters which are simply a waste of time. Meetings are still the best medium for encouraging the preparation of technical papers and for ensuring that members keep up to date with the latest information available.

There are two factors in a meeting, the technical and the social. The value of the social benefits should never be underestimated, but the technical benefits of a meeting must be predominant and it is on the technical side that meetings are becoming less effective.

The Institute must give some very serious thought to this subject. It must find some way of vitalizing its meetings so that they maintain their rightful place in the life of the profession. Suggestions have been put forward from time to time, and perhaps the most promising is one which would retain the half-day sessions but change their form; instead of the presentation of three papers of more or less equal length, each session would begin with the presentation, in extenso, of a paper reviewing the state of the art, followed by a series of very short presentations, summarizing and introducing dependent papers which would be available to the audience in written form. The scheme turns on the availability of preprints – which are expensive– and the availability of speakers. Speakers capable of giving full-length papers are something of a rarity in Canada but there is plenty of work being done on which these short, what we have called "dependent" papers, could be based, and there are plenty of speakers who could say a few words and write a couple of pages about their own particular little bailiwicks. Among its other advantages this scheme would spread the load of preparing papers; the preparation of a lot of short papers by a lot of people would be much less of a burden than the preparation of a few long papers by a few people.

This is but one proposal. There are others, such as the well tried and often successful panel discussion. The National Programmes Committee is fully aware of the problem and would welcome suggestions.

## TCA's VICKERS VANGUARD

Trans-Canada Air Lines has recently introduced the new Vickers Vanguard into service on their short-to-medium length routes across Canada and to the USA, and on the longer routes south to Bermuda and the islands in the Caribbean. This aircraft, which has a maximum range of 2,800 miles, is particularly well suited for service on routes in the 600 to 2,000 mile range. It is interesting to note that the Vanguard will be as fast as the pure jets on routes of up to 1,000 miles in length.

The layout and basic concept of the Vanguard bears an obvious family resemblance to the Viscount; the aircraft has been built to fly in the same altitude regime — up to 24,000 ft — and the fail-safe design is similar to that of the smaller aircraft.

But in appearance and exterior design, the aircraft is quite different.

The Vanguard has a "double-bubble" fuselage, looking in cross-section like a slightly flattened figure 8. The large cargo holds, with a working height of more than 4 ft and capable of holding 1,360 cu ft of freight — up to 10,000 lb — are located in the lower section of the fuselage, below the passenger floor. The cargo doors are located on the starboard side of the aircraft and the passenger entrances on the port side, permitting simultaneous loading and unloading of passengers, baggage and freight without congestion. In keeping with the workhorse design of the Vanguard, the floors of the cargo holds are only 4½ ft above the ground, allowing easy access.

The cargo capacity weight without passengers is 25,500 lb, which makes the aircraft ideally suited for TCA's Canadian and trans-border operations and routes south to the Caribbean, where there is often a substantial demand for cargo space in one direction only. This will enable TCA to operate an almost all-cargo service, without resorting to uneconomical one-way operations with freight-only aircraft, while maintaining preferred passenger schedules.

The Vanguard carries 96 passengers in four cabins. The two economy class cabins in the forward section of the aircraft seat 25 passengers each in five abreast seating, while the two first class cabins seat 28 and 18 passengers, respectively, in four abreast seating. Starting at the forward end, the cabin layout is as follows: immediately aft of the flight deck is the economy class passengers' entrance on the port side and the forward galley on the starboard side; behind this the two economy class cabins are located. These two cabins are separated by the forward washrooms. Aft of these two cabins is the 25 passenger first class cabin which is separated from the 18 passenger first class cabin by the galley and the passenger entrance. Aft of this cabin is located a double washroom.

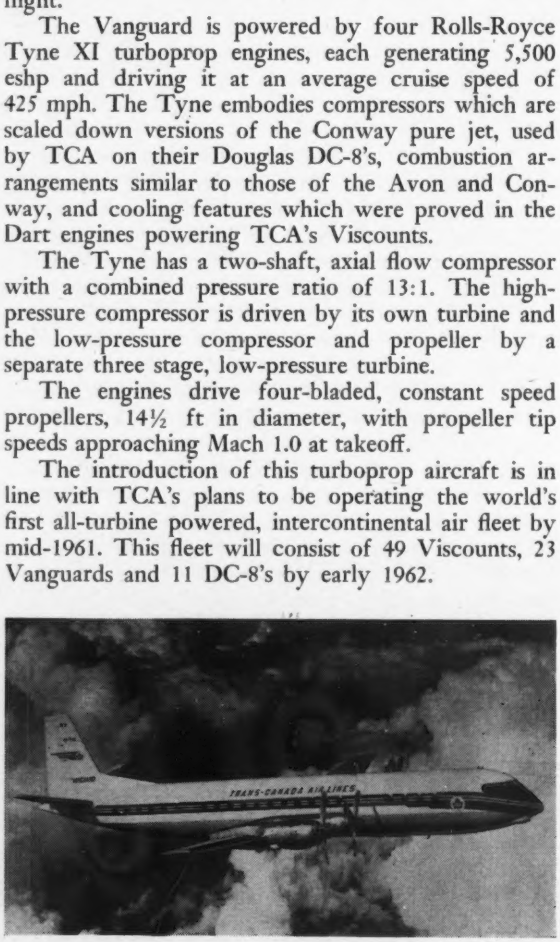
The seats in all cabins have built-in trays. In addition, the first-class chairs have cup trays which slide out of the arm rest between each pair of seats. All passenger service fixtures, such as individual reading lights, cold air outlets and stewardess call buttons, are located on the overhead luggage rack. At both passenger entrances, hydraulically-operated air stairs are installed. These stairs fold up into the entrance passageway and are shrouded by a curtain during flight.

The Vanguard is powered by four Rolls-Royce Tyne XI turboprop engines, each generating 5,500 eshp and driving it at an average cruise speed of 425 mph. The Tyne embodies compressors which are scaled down versions of the Conway pure jet, used by TCA on their Douglas DC-8's, combustion arrangements similar to those of the Avon and Conway, and cooling features which were proved in the Dart engines powering TCA's Viscounts.

The Tyne has a two-shaft, axial flow compressor with a combined pressure ratio of 13:1. The high-pressure compressor is driven by its own turbine and the low-pressure compressor and propeller by a separate three stage, low-pressure turbine.

The engines drive four-bladed, constant speed propellers, 14½ ft in diameter, with propeller tip speeds approaching Mach 1.0 at takeoff.

The introduction of this turboprop aircraft is in line with TCA's plans to be operating the world's first all-turbine powered, intercontinental air fleet by mid-1961. This fleet will consist of 49 Viscounts, 23 Vanguards and 11 DC-8's by early 1962.



# DEVELOPMENT AND CHECKOUT OF THE NASA MERCURY CAPSULE†

**by G. B. North***

***McDonnell Aircraft Corporation***

THE Mercury Man-in-Space Project includes twenty capsules, four of which had been delivered to the National Aeronautics and Space Administration by August 1960. The contract was awarded in February, 1959, and most of the developmental and qualification testing has been completed, including the first two launches of production capsules. This paper will describe some of the development and checkout of the capsule and its systems. First, it would be worthwhile to review briefly the mission profile and flight systems.

## MISSION AND CAPSULE DESCRIPTION

Two basic Mercury missions are planned — the Redstone ballistic trajectory of approximately 200 miles range, and the Atlas three orbit mission. Figure 1 shows the orbit mission sequences from launch to impact. The Atlas booster stage separates at about 35 miles altitude, and the escape tower is jettisoned 20 seconds later. Acceleration increases to a maximum of 8g just prior to sustainer shut-down and capsule separation, which occurs at approximately 25,000 ft/sec and 105 nautical miles altitude. Orbit is performed with the heat shield forward to permit rapid retrograde if necessary. During re-entry, the capsule reaches 8g maximum deceleration at about 20 miles altitude. The drogue chute and main chute are deployed at 42,000 ft and 10,000 ft, respectively. Total flight time for this mission is slightly less than 5 hours.

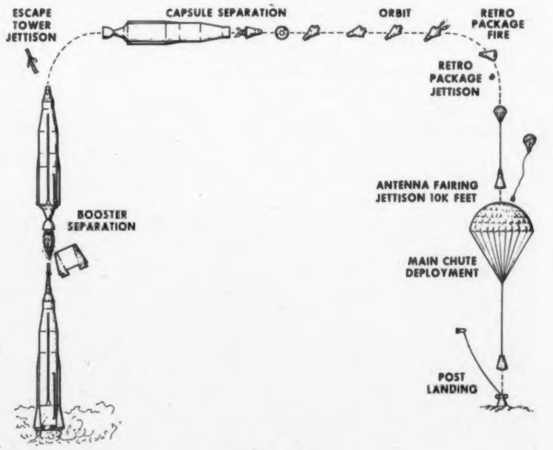



**Figure 1**
**Orbit mission sequences**

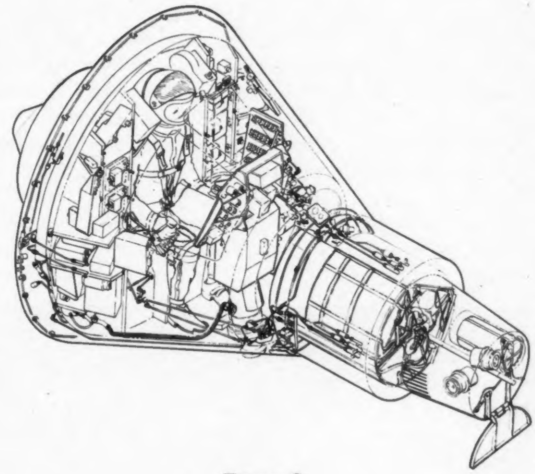


**Figure 2**
**Interior arrangement**

Figure 2 is a drawing of the capsule interior. The toroidal tanks for the reaction control hydrogen peroxide are located between the heat shield and the large pressure bulkhead. The roll thrust nozzles are on the conical surface near the heat shield, and the pitch and yaw nozzles are seen on the cylindrical section. Communications, instrumentation, autopilot and electrical system components are installed primarily at each side of the pilot's support couch. The oxygen bottles and most of the environmental control system are located below the pilot. The main instrument panel is mounted on the periscope assembly. The main and reserve parachutes occupy part of the cylindrical section, and the drogue chute is installed in the jettisonable antenna fairing. This antenna fairing also contains the pitch and roll infra-red horizon scanners. A fairly detailed description of the capsule and its flight systems is presented in Reference 1.

## DEVELOPMENT AND QUALIFICATION TESTS

To provide Project Mercury with maximum mission reliability and to minimize development costs and delays, the capsule systems incorporate existing hardware wherever practical. Development and qualifica-

†Paper read at the Joint I.A.S./C.A.I. Meeting in Montreal on the 17th October, 1960.
*Project Crew Station Engineer

tion of new equipment has been performed by the NASA, by Military facilities, by McDonnell, and by McDonnell's subcontractors.

**Qualification requirements**

Qualification requirements are expanded beyond those specified in the standard aircraft environmental testing specification MIL-E-5272A, especially with regard to temperature, pressure, pure oxygen atmosphere, vibration, shock, acceleration and acoustic noise. To provide continued operation in the event of cabin decompression, systems are designed to operate essentially in vacuum conditions. Landing impact considerations dictate that capsule structure and equipment attachments withstand shock loads of 100g. System operation under extreme booster and aerodynamic acoustic noise has not been a major design requirement on aircraft; however, the Mercury capsule system is specified to function with an internal capsule noise of 135 db and with external noise up to 150 db. System reliability understandably receives major emphasis, and equipment subcontractors are required to report all failures during development as well as during qualification testing. Life cycle, endurance and reliability series tests are required when applicable.

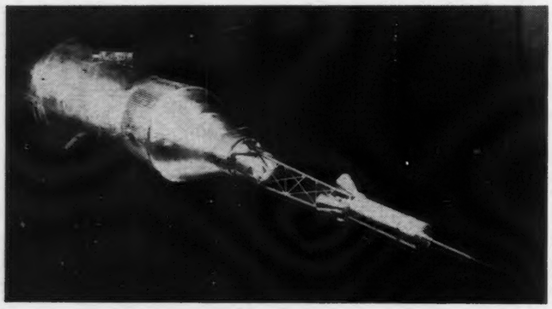


**Figure 3**
**7% model in Ames 9 × 7 ft supersonic tunnel**

**Aerodynamic tests**

Wind tunnel testing has consumed about 3,400 hours of occupancy time in 24 different wind tunnels at the following facilities:

| *Facility* | *No. of Tunnels* |
|---|---|
| Langley Research Center, Virginia | 13 |
| Ames Research Center, California | 6 |
| Arnold Engineering Development Center, Tennessee | 3 |
| Daingerfield, Texas | 1 |
| McDonnell Aircraft, St. Louis, Missouri | 1 |

These tests have varied in speed from low subsonic to Mach 21, and the models have ranged in size from 2.2% to full scale. The wind tunnel tests have served to evaluate the following aspects:

(1) static and dynamic stability,
(2) pressure distribution,
(3) heat transfer,
(4) airflow separation,
(5) vibration and flutter,
(6) drogue chute effectiveness (in Langley 20 ft spin tunnel), and
(7) escape rocket jet effects.

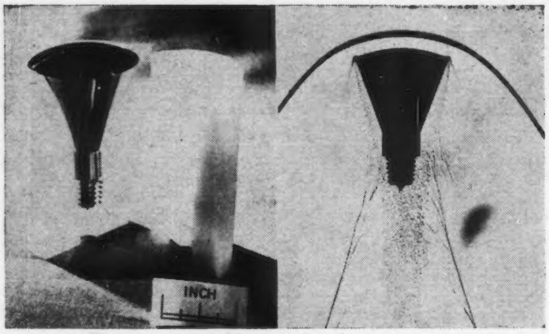



**Figure 4**
**2.2% model in Ames ballistic tunnel**

Figure 3 presents a picture of a 7% scale model with escape tower and Atlas booster. This model was tested between Mach 1.4 and 2.6 for static stability and pressure distribution evaluations in the Ames 9 × 7 ft supersonic tunnel.

Figure 4 shows two views of a 2.2% scale model at the Ames 203 ft ballistic tunnel. The left view includes the support cradle which separates upon launch. The right view is a shadowgraph of this model in a Mach 3.4 trajectory.

Additional aerodynamic data have been obtained from rocket launches of the following scale model capsules:

| *Purpose* | *No. of Launches* |
|---|---|
| Big Joe (Atlas) re-entry test of full-scale model | 1 |
| Little Joe escape tests of full-scale models | 4 |
| Off-the-pad escape tests of 30% models | 5 |
| Off-the-pad escape tests of two full-scale models and one production capsule | 3 |
| Re-entry test of rocket-boosted 14% model | 1 |

**Impact tests**

Full scale boiler-plate capsules have been dropped on land and on water to determine impact load factors and to develop the impact bag. Figure 5 shows a boiler-plate capsule with impact bag in the drop-test rig at McDonnell. This installation has been employed for capsule drops at various combinations of sink speed, drift speed and tilt angle.

To gain additional information on animal impact tolerance, four pig drops were conducted in a vertical drop rig. Production-type, crushable aluminum honeycomb posts, which were developed in previous

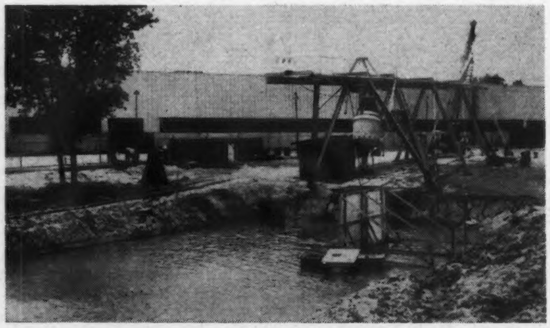


**Figure 5**
**Full scale drop test installation**

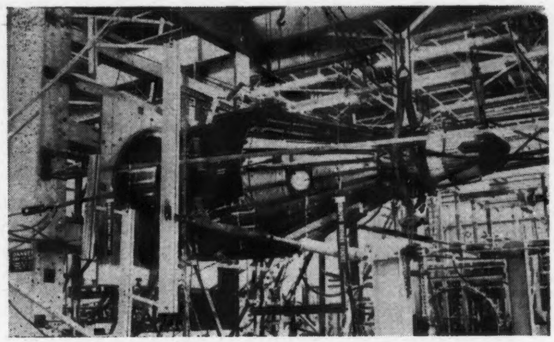


**Figure 6**
**Adapter static test**

tests, were installed between the molded couch and the simulated heat shield to absorb some of the animal's impact energy. The drop assembly was impacted on level sand at velocities from 30 to 35 fps. The tests produced couch load factors between 38g and 59g with onset rates between 55,000 and 59,000g/sec. Medical examination of the pigs indicated that no permanent or disabling damage was received. Although high accelerations were obtained during these tolerance tests, installation of the impact bag on production capsules should reduce peak longitudinal acceleration to approximately 17g.

A drop-test program with an anthropomorphic dummy in a production couch assembly is in progress. Production capsules with and without impact bags also are scheduled for drop tests at McDonnell.

#### Adapter test

The Atlas adapter was static tested to loads far greater than those which could occur during flight. The loads during this test were 50% greater than those which would be encountered with a guidance failure, which could provide an angle of attack of nearly 10° at maximum dynamic pressure. The test was conducted in the McDonnell laboratory with a production capsule and Atlas dome as shown in Figure 6. No failures occurred during this test.

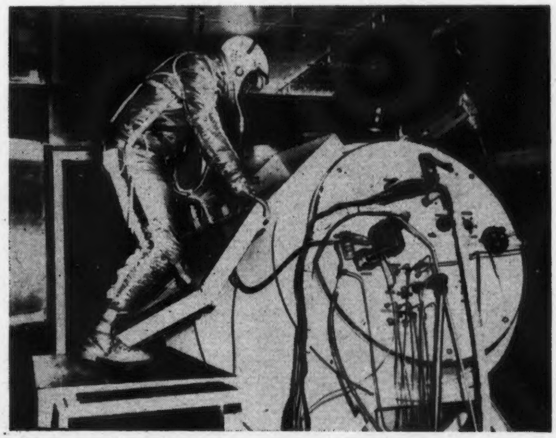


**Figure 7**
**Environmental control system test capsule**

#### Environmental control system

The environmental control system, which provides the astronaut with a 5 psia oxygen atmosphere, was scheduled for completion of all qualification and reliability testing in September, 1960. One of the most extensive component testing programs has been that which was required to develop and qualify the 7,500 psi oxygen bottles.

Over 100 hours of manned environmental control system operation have been accomplished in altitude chambers. These tests were conducted in sealed boiler-plate capsules and were instrumented to evaluate the environmental control system operation and the physiological effects on the subject. Figure 7 shows a subject in a Mercury full pressure suit entering the test capsule in the McDonnell altitude chamber. This capsule is equipped to simulate heat and pressure profiles for the various phases of the mission, both in the normal and the emergency modes. Tests indicate that re-entry heat loads are not critical to the capsule occupant, primarily because of the short time duration of the re-entry heat profile and the temperature lag characteristics of the closed circuit system. This environmental control system capsule will be delivered to the NASA for the training of pilots and medical monitors.

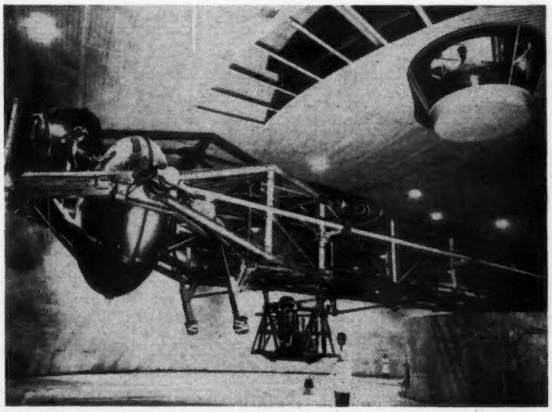


**Figure 8**
**NADC centrifuge**

The pressure suit, which comprises part of the environmental control circuit, also has been worn by subjects during several hundred hours of additional Mercury testing, including the following:

(1) main panel and console development in capsule mock-up,
(2) support and restraint development,
(3) manual control system development in analog simulator,
(4) cockpit equipment development,
(5) pressure suit evaluations,
(6) heat chamber tests, and
(7) egress procedure development.

All of the above tests, except the last two, were conducted both with the suit uninflated and with the suit at 5 psia (decompressed cabin simulation).

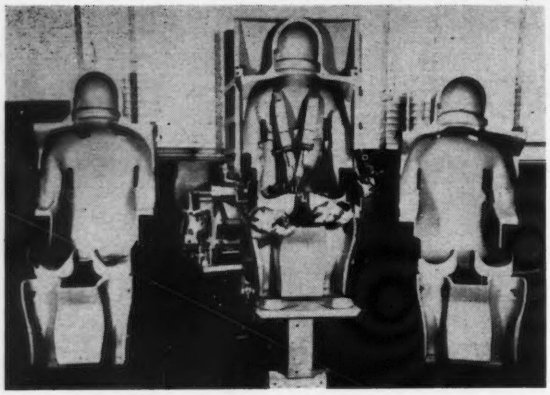


**Figure 9**
**Centrifuge couches**

**Support couch and restraint**

The design configuration of the pilot support couch and restraint system has resulted from experience obtained on acceleration devices, such as the centrifuge at the Naval Air Development Center and the sled tracks at Holloman Air Force Base. Figure 8 is a view of the NADC centrifuge at Johnsville, Pennsylvania. This centrifuge has a two-gimbaled gondola on a 50 ft radius arm and can provide loadings up to 40g and acceleration increase rates up to 10g/sec. Figure 9 shows three Mercury centrifuge couches, the center one being installed in a centrifuge support structure with the restraint straps. The center couch installation also shows the three-axis hand controller at the pilot's right hand and the escape handle at the pilot's left hand. The Mercury centrifuge program has provided the pilots with the capability of closed-loop damping control during re-entry acceleration profiles.

**Egress from capsule**

After impact, the astronaut normally will remain in the capsule to utilize the recovery aids. However, if it is necessary to make an emergency exit from the capsule, two egress routes are available – through the small pressure bulkhead and the recovery compartment, or through the side hatch. Figure 10 shows

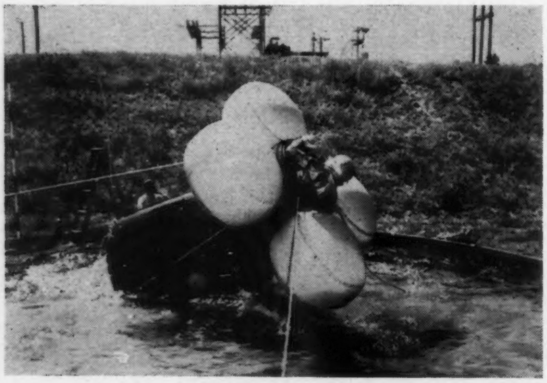


**Figure 10**
**Pilot egress test**

an egress through the recovery compartment of a mock-up capsule in a water tank at McDonnell. This egress route requires that the pilot remove and stow the right portion of the main instrument panel, remove and stow the small bulkhead hatch, and disconnect and push the parachute container from the recovery compartment before he maneuvers out of the capsule. This view includes flotation bags, which were later deleted when the capsule gained hydrodynamic stability by the addition of the impact bag. The ropes attached to the top of the recovery compartment were used to rock the capsule for rough water simulation.

Egress through the side hatch in rough water causes the capsule interior to become swamped and necessitates rapid egress before the capsule sinks. The side hatch is quickly released by detonating redundant strands of explosive which are routed adjacent to the 70 hatch bolts. MDF explosive has been developed to cause tension failure of the hatch bolts with no shrapnel being directed into the capsule.

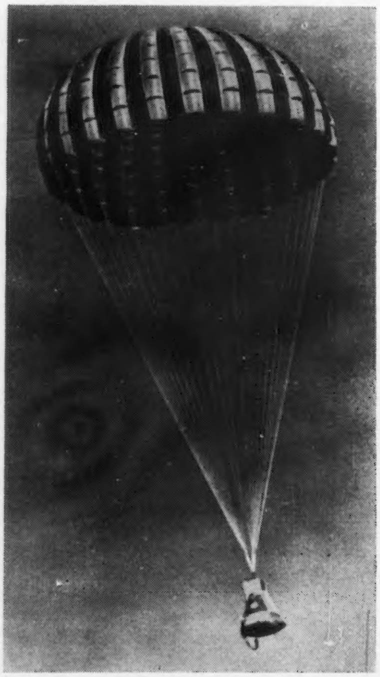


**Figure 11**
**Main parachute test at the Salton Sea**

**Parachute tests**

The capsule recovery system development and qualification included the following parachute flight test program, most of which was conducted from El Centro, NAS, California:

| *Test* | *No. of Deployments* |
|---|---|
| Main and Reserve chute | |
| capsule drops | 55 |
| bomb drops | 89 |
| Drogue chute | 70 |
| Pilot chute | 90 |

The boiler-plate capsule drops occurred at the Salton Sea from an Air Force C-130 at 30,000 ft or from a Marine HR2S helicopter at low altitude to

simulate off-the-pad abort conditions. Figure 11 shows one of these capsules on the 63 ft ringsail main chute. Most of the main and reserve chute bomb drops were made from Navy A4D, AD and F3D airplanes. Main chute development tests resulted in a 12% reefing for 4 seconds to prevent the opening loads from exceeding the 10,000 lb design limit. The drogue chute deployments include 14 bomb drops from a NASA F-104 up to Mach 1.5 and 60,000 ft and 3 bomb drops from an Air Force F-100 at 42,000 ft. The drogue chute deploys at 42,000 ft and serves to stabilize and decelerate the capsule prior to main chute deployment at 10,000 ft. If the drogue chute fails to deploy, the main chute and its attachments have adequate strength to withstand the main chute opening loads.

**Pyrotechnics**

The capsule pyrotechnics, which include items such as rockets, reaction control system, explosive bolts, ejectors, cartridges, valves and Sofar bombs, comprise a total of over 25 different pyrotechnic types, most of which have been used in previous vehicle installations.

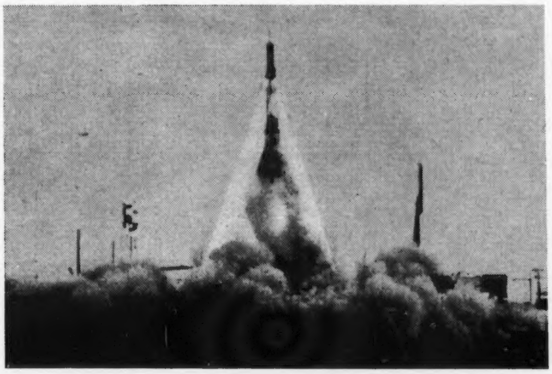


**Figure 12**
**Off-the-pad escape test at Wallops Island**

The escape rocket was developed for Project Mercury and has undergone 59 development and qualification firings. In the event of booster malfunction on the pad, the escape rocket, of about 60,000 lb maximum thrust, can be used to propel the capsule to approximately 2,500 ft altitude. Figure 12 shows number one production capsule in an off-the-pad escape test at Wallops Island, Virginia.

The reaction control system, which consists of two independent subsystems — the manual and the automatic — was scheduled to receive 100 mission-type tests on each subsystem by the 30th November to complete final reliability qualification.

**CAPSULE CHECKOUT**

After completing final assembly, the capsules undergo an operational checkout which can be compared in purpose with airplane production acceptance flights. This checkout consists of two phases — capsule system tests at McDonnell and the capsule mission preparation at the launch facility.

| PHASE I | PHASE II |
|---|---|
| INDIVIDUAL SYSTEM OPERATIONAL TESTS (ISO) | SIMULATED MISSION |
| Electrical | Pre-launch |
| Sequential operation | Booster operation |
| Instrumentation | Booster cut-off |
| Communication | Tower separation |
| Automatic stabilization and control | Tail-off |
| Environmental control | Capsule separation |
| Reaction control | Capsule orientation |
| | Orbit phase |
| SUPPLEMENTARY TESTS | Retrograde programming |
| Vibration | Retrograde rockets |
| Pressurization and leakage | Re-entry and damping |
| Altitude chamber | Drogue chute deploy |
| | Main chute deploy |
| | Impact |
| | Post-landing |

**Figure 13**
**Capsule systems test**

**Capsule system tests (CST)**

Before system components are installed for CST, they have been subjected to vendor tests and to pre-installation acceptance tests at McDonnell. The CST program is outlined in Figure 13. The program consists initially of detailed individual system tests to verify wiring and connections, and to check that the systems perform as specified. CST is completed by testing combined systems during simulated mission sequences. The individual system and simulated mission tests are conducted in the controlled cleanliness of the air-conditioned "white room".

In the vibration chamber, Figure 14, the capsules receive vibration inputs along three mutually perpendicular axes. An altitude chamber is utilized to check the pressure-controlling functions of the cabin and suit environmental control systems.

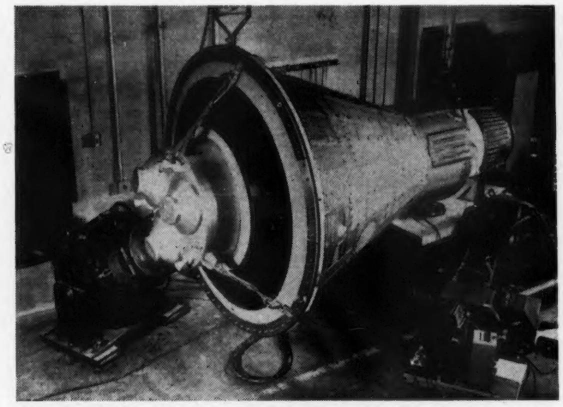


**Figure 14**
**CST vibration test**

**Capsule checkout at launch facility**

Upon completion of CST at St. Louis, the capsules are ferried by cargo aircraft to the launch sites. All production capsules are scheduled to be launched at Cape Canaveral with the exception of two at Wallops Island, Virginia. At Cape Canaveral, checkout procedures are conducted at the hangar and on the launching pad in the sequence indicated in Figure 15. This chart shows that upon completion of receiving inspection, the capsule goes into a separate area for

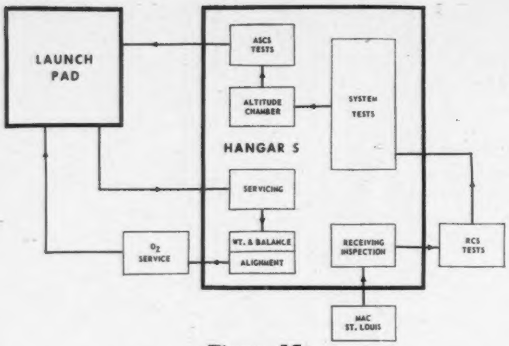



**Figure 15**
**Mercury-Atlas capsule flow chart — Cape Canaveral**

reaction control system test, where the following tests are performed:
(1) leakage test of helium and hydrogen peroxide circuits,
(2) decomposition surveillance with 35% and 90% hydrogen peroxide, and
(3) static firing of thrust chambers.

The system tests are conducted in an air-conditioned room and consist primarily of sequential and combined system tests to verify that the capsule is ready to proceed to the following tests. If malfunctions exist, individual system checks will be conducted as necessary. Over 550 items of ground support equipment, ranging from trailers to special tools, are required to conduct these system tests and to perform other capsule preparations. Checkout and telemetry, 32 ft semi-trailer vans are connected to the capsule by through-the-hatch cables and by the umbilical cable. These trailers control and monitor the capsule functions. An observer inside the capsule operates controls and observes indications during most of the testing in the hangar and on the launch pad. Electric clocks in the checkout trailer automatically record cumulative system operating time and thereby aid in preventing excessive operation of the more critical components.

The altitude chamber, Figure 16, was designed primarily to accommodate the Mercury capsule and has a maximum altitude capability in excess of 200,000 ft. Manned and unmanned capsule tests will be conducted in this chamber. The ASCS (automatic stabilization control system) dynamic test fixture can provide capsule rotation up to 15°/sec in each of the three axes. After ASCS tests, Figure 15 indicates that the capsule makes the first two visits to the launch pad. During this first visit, the following checks are accomplished:
(1) physical mating of the capsule to the booster,
(2) physical mating of the test equipment with the service tower and blockhouse,
(3) simulated flight test sequential operation and RF radiation checks, and
(4) static firing of Atlas booster.

Figure 17 shows the gantry being moved away from the booster and capsule prior to static firing.

Upon return to the hanger, cabin equipment will be installed and serviced, the recovery components will be installed, and weight and balance, and escape rocket alignment checks will be performed. Servicing of the high pressure oxygen bottles is conducted outside the hangar just prior to final transport to the launch pad. Final capsule preparation consists of the following launch pad operations:
(1) simulated flight test,
(2) final servicing of reaction control, environmental control and instrumentation systems,
(3) connection of pyrotechnics, and
(4) astronaut insertion and final countdown.

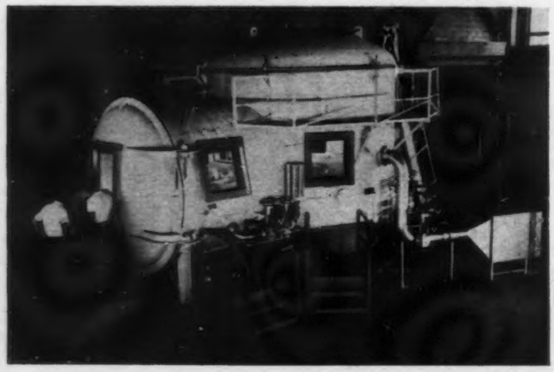


**Figure 16**
**Altitude chamber**

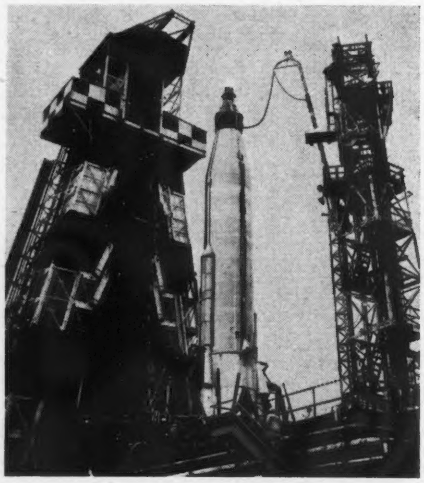


**Figure 17**
**Capsule No. 4 on Atlas**

**CONCLUSION**

This paper has briefly described a few of the tests and preparations which occur between the design and launch of the Mercury capsule. Several unmanned flights will be conducted before the capsule and its systems will be considered adequately flight qualified for manned occupancy. Primates are scheduled to precede men both in the ballistic and the orbital missions. Information gained from Project Mercury, regarding the capabilities of capsule systems and man during orbital flight, should be of value for advanced orbital and interplanetary projects.

REFERENCE

(1) Faget, M. A., and Piland, R. O. – *Mercury Capsule and its Flight System*, Aero/Space Engineering, April, 1960.

# AN ECONOMIC EVALUATION OF THE DESIGN VOLUME AND PAYLOAD OF CARGO AIRCRAFT†

**by C. E. B. McConachie,* M.C.A.I., and M. A. Bajwa****

***Canadair Limited***

SUMMARY

The design volume and the payload of a cargo aircraft determine the "achieved payload" in a projected cargo operation, defined by the probable payload requirements and the associated densities.

The economics of the variations in basic design volume and payload will be governed by the improvements that can be accomplished in the achieved payload. The additional cost of offering a higher volume and/or payload version of the aircraft will be limited by the increase in revenue expected, due to higher achieved payloads.

It is observed that the density variations have the most severe effect on the achieved payloads for a projected operation. A slight decrease in the mean warehouse density requires a proportionally larger volume increase, in order to maintain the same achieved load factors.

This type of analysis also indicates that on most currently proposed cargo aircraft, the weight limitations are likely to be less severe than the volume limitations. Consequently, a volume increase might, in some cases, be economically justified for a situation where the lower density distribution, as used in this analysis, was experienced.

The methods developed in this analysis for considering the design volume and payload are currently being used at Canadair, as a means of evaluating the operating economics of the CL-44D4 cargo aircraft and its future developments. In co-operation with Canadair, a major US cargo carrier has applied this analysis effectively in determining the economic feasibility of performing certain volume increasing modifications to its present fleet of piston-powered cargo aircraft.

**INTRODUCTION**

ONE of the major factors determining the economics of a cargo aircraft is the design volume/payload relationship. Most aircraft operating cost evaluations consider the payload available, but seldom consider the full economic implications resulting from the volume offered in a cargo aircraft.

The design payload and density of the cargo to be carried together determine the volume requirements of the aircraft. Since the available payloads and densities usually vary from trip to trip, it is essential that the effect of the design volume on the airline's economic picture be studied over the entire range of payload and density variation for a projected operation.

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To operate economically an aircraft must of necessity be volume-limited on some trips, otherwise a completely impractical size would be necessary to carry the greatest payload expected at the lowest density. Because of this volume limitation, the sum of the achieved payloads will be less than the sum of the total available payloads in any projected operation. A change in the design volume will affect the payloads that can be achieved as well as the basic operating cost of the aircraft.

The economics of volume variations should be studied in terms of the revenue earning capability of the proposed volume change. To be economically justified, the aircraft price and operating cost increase required to achieve greater volume, for example, should be less than the additional revenue generated over the aircraft's life, due to the proposed volume increase. A similar statement can be made regarding the economics of weight reduction in aircraft.

Based on typical payload and density variations, a method is presented in this analysis for the calculation of the achieved payload for an available aircraft volume and maximum payload. The application of the achieved payload concept to the economic evaluation of a change to an aircraft's design volume is also shown.

**CARGO PAYLOAD AND DENSITY DISTRIBUTIONS**

The variability of a projected cargo operation can best be defined by the frequency of occurrence of the trip payloads and the density of the payloads. The resulting payload and density distribution curves are the basic variables determining the volume requirements of the aircraft required to satisfactorily handle the operation.

In a large cargo operation, the payload lifted per trip can be considered to be random, and as such the frequencies are most likely to be normally distributed about the mean.

The experience of a major US transcontinental operator indicates that their payload variations follow closely the pattern of a Normal or Guassian Distribution, with the standard deviation being equal to 11% of the mean. Based on these statistics, payload distri-

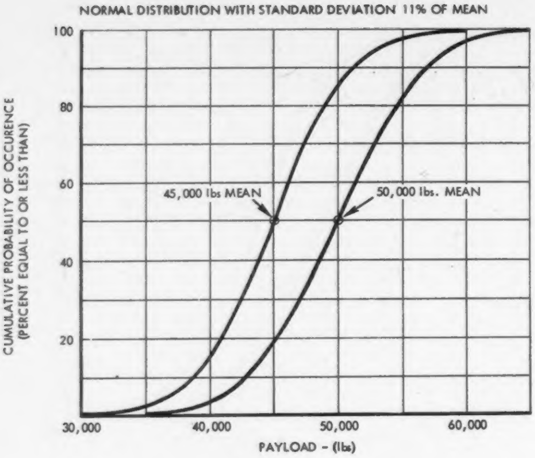


**Figure 1**
**Projected payload distributions**

butions for an operator with mean trip payload requirements of 45,000 lb and 50,000 lb are shown in Figure 1.

Variations in cargo densities are much more critical than variations in payload, in determining the adequacy of an aircraft's volume. In most present commercial air operations, cargo shipment densities vary from 4 lb/cu ft to 22 lb/cu ft, as measured in a warehouse. In order to evaluate the future trends in air cargo densities, Canadair has established a cooperative research programme (the results of which will soon be available) with a major US cargo carrier. For this present study we have used the two typical density distributions outlined below and shown in Figure 2:

(a) US domestic scheduled operations — density distribution with a mean of approximately 10 lb/cu ft, and

(b) non-scheduled (military operations) — density distribution with a mean of approximately 13.5 lb/cu ft[1].

In this study the aircraft volume is considered to be the net usable volume or that volume remaining after allowing for unusable space as well as space lost due to stacking inefficiencies. Correspondingly, the density considered is for the aircraft load, and it has been assumed to be the same as the warehouse density.

## CALCULATIONS OF ACHIEVED PAYLOADS

An economically designed aircraft will encounter, on a certain percentage of occasions, payload restrictions due to volume or weight limitations. The average achieved payload, or payload carried on the average, will, therefore, be less than the average of the projected or offered payloads.

The quantity of excess payload can be calculated by using the probabilities of occurrence of the payload and density combinations which result in volume- or weight-limited conditions.

Let the payload and density range have $m$ intervals such that

$W_i$ = payload value for the $i$th interval

$p_i$ = probability of occurrence of $W_i$

$D_j$ = density value for the $j$th interval

$q_j$ = probability of occurrence of $D_j$

Volume required $(V_{ij}) = W_i/D_j$

*Volume-limited condition*

When the volume required is larger than volume available, the excess payload or the payload that cannot be carried on a particular trip is $(W_i/D_j - V_a)\, D_j = W_i - V_a D_j$

where $V_a$ = net usable volume.

Since a trip is represented by the payload/density combination, the probability of occurrence of a trip with $(W_i, D_j)$ combination will be the product of the probabilities of $W_i$ and $D_j$, i.e. $(p_i \times q_j)$.

Therefore, "probable excess payload" is

$$(W_i - V_a D_j) \times (p_i\, q_j) \tag{1}$$

*Weight-limited condition*

When the projected payload is larger than the maximum allowable trip payload, and volume required is less than volume available, the excess payload is $(W_i - W_m)$

where $W_m$ = maximum allowable trip payload; and probable excess payload is

$$(W_i - W_m) \times (p_i\, q_j) \tag{2}$$

Then, the mean probable excess payload for an operation with $N$ trips will be

$$[\sum_{i=j=1}^{m} (1) + \sum_{i=j=1}^{m} (2)]/N \tag{3}$$

The mean probable achieved payload is

$$W_a - (3) \tag{4}$$

where $W_a$ is "mean projected payload" or mean of the payload distribution, and the mean "probable achieved load factor" is

$$[W_a - (3)]/W_a \tag{5}$$

**Equal probability intervals**

The calculation of excess payloads can be simplified by using payload and density intervals with equal

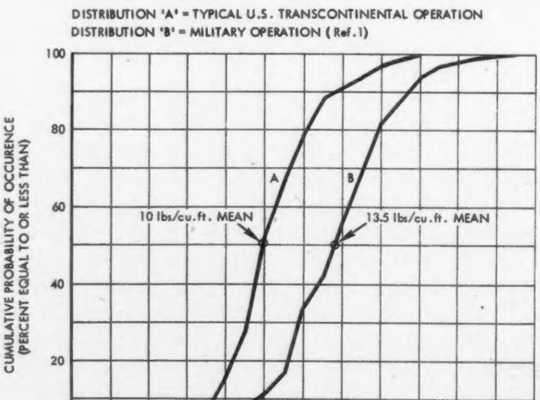


**Figure 2**
**Density distributions**

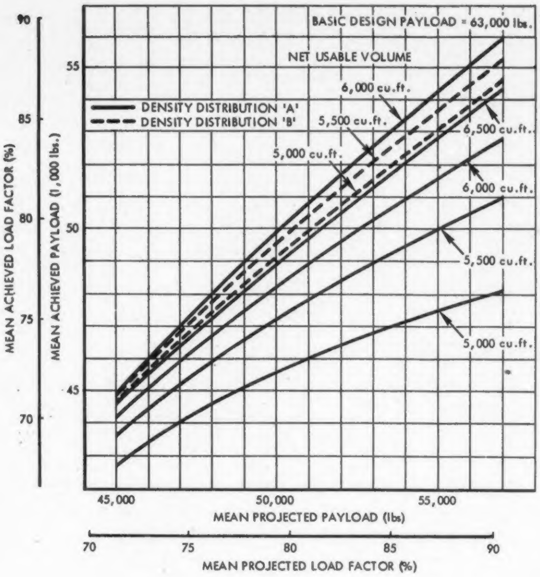


**Figure 3**
**Projected vs achieved payload**

probabilities of occurrence. This can be accomplished by dividing the payload and density range into ten intervals, for example, such that each has 10% probability of occurrence. Then, out of 100 possible combinations of payloads and densities each will have a probability of occurrence of (10/100) × (10/100) or 1%. Each trip, being the result of a payload and density combination, will also have 1% probability of occurrence.

Thus, mean probable excess payload is

$$\left[\sum_{i=j=1}^{m} (W_i - V_a D_j) + \sum_{i=j=1}^{m} (W_i - W_m)\right]/N \qquad (6)$$

The mean achieved payload and achieved load factor will be found as in Eqs. (4) and (5).

#### Use of random numbers

An operation would require an infinitely large number of trips to utilize the entire payload/density occurrences given by the respective distributions. Since a typical commercial cargo operation is of relatively "small" magnitude, it would be more accurately represented by a random sample of the payloads and densities.

For the purpose of these calculations, the use of random numbers is quite appropriate and convenient. A two digit random number can be considered to represent a trip, where the first digit corresponds to an assigned payload interval and the second to an assumed density interval. The use of approximately 100 random numbers combinations yields an acceptable level of accuracy.

The use of random numbers is especially useful when additional variables limiting the payload, such as airport and enroute temperatures, winds etc, are to be considered. When four probability distributions are being considered, a trip will be represented by a four digit random number.

### VOLUME VARIATION AND PROBABLE ACHIEVED PAYLOAD

As developed above, the payload which can be achieved by a certain aircraft design volume is determined by the probable payload and density distributions. The effect of volume variations on achieved payload for two density distributions is illustrated in Figure 3. It will be observed that the density variations have the most pronounced effect on the achieved payload.

From Figure 3 it is also apparent that as the mean projected payload is increased relative to the maximum payload of the aircraft, i.e. a higher projected load factor, the excess payload increases very rapidly. In fact it would appear that to plan for a load factor in excess of 75% to 80% would result in an unacceptably large percentage of the payload being left behind.

### IMPROVEMENT IN ACHIEVED PAYLOAD

If an operator were to accept only that quantity of payload which the aircraft can carry on a particular flight, any amount of payload in excess of the volume- or weight-limited payload could be considered a loss of business. However, it is often possible to improve the achieved payload by carrying some of the excess payload from one flight on the subsequent flights on which weight and volume are available.

The exact quantities that can be used on the subsequent flights operating with below-capacity payloads will depend on a number of factors, such as load planning, priority rating of the shipments and the frequency of flights on a particular route.

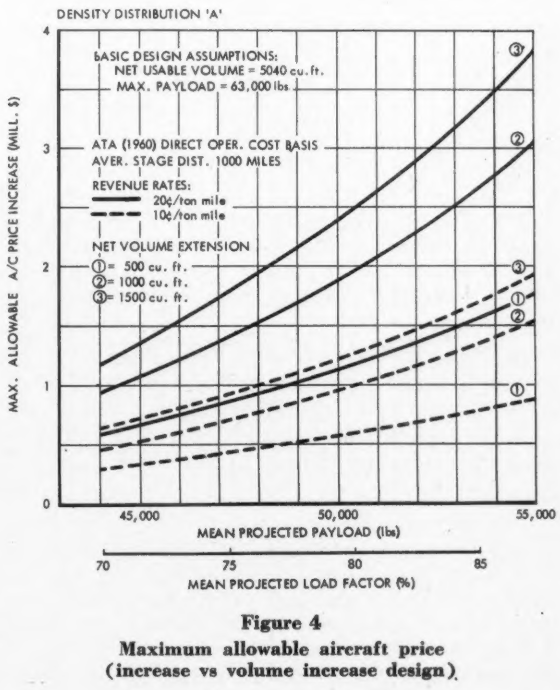


**Figure 4**
**Maximum allowable aircraft price (increase vs volume increase design)**

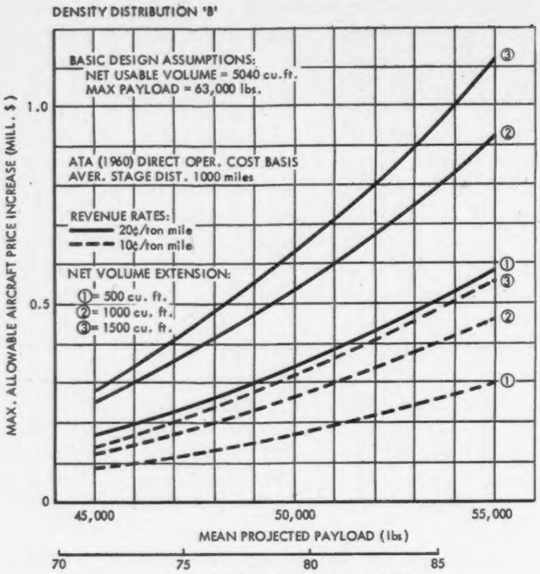


**Figure 5**
**Maximum allowable aircraft price (increase vs volume increase design)**

A very good approximation of the effect of utilizing the excess payload on subsequent flights can be obtained by using the random number analysis in which the excess payload capacity of subsequent flights can be established.

### EFFECT OF VOLUME/PAYLOAD INCREASE ON REVENUE

Depending on the projected load, an improvement in the achieved payload will result from either an increase in the basic design volume or design payload, since a reduced percentage of volume- or weight-limitations will be experienced.

Using the method for calculation of the probable achieved payload, as previously outlined, the net increase in the achieved payload and, therefore, the increase in revenue can be determined.

For a particular operation the economics of any proposed design change will depend on the additional revenue due to higher achieved load factors and the cost of effecting that change to the basic aircraft.

### VOLUME VARIATION AND AIRCRAFT COST

The economic feasibility of improving the basic design volume of an aircraft should be studied from the standpoint of the increased revenue required to offset the resulting changes to the basic price and operating costs.

Such an analysis was applied to the Canadair CL-44D4 aircraft, to determine the maximum amount the aircraft price could be increased for a given density distribution and different mean projected payloads. The results are shown in Figures 4 and 5, and indicate that the amount the operator can pay for a volume increase is directly related to the projected load factor and cargo tariff. For example, it is practical to pay as much as \$1.8 million per aircraft for an additional 500 cu ft, if it is intended to attempt an operation at a mean payload of 55,000 lb (87% load factor) and a 20c/ton mile tariff. For a 10c/ton mile tariff and a lower mean payload of 45,000 lb (71% load factor), the operator could only afford to pay up to \$330,000 additional per aircraft or 18% of the previous value. If the volume increases cost less than the above figures, the operator stands to increase his profit. A more detailed analysis of this particular problem is described in the Appendix.

### PAYLOAD VARIATION AND AIRCRAFT COST

As in the case of volume changes, the feasibility of any increase in the basic design payload will be determined by the effects it will have on the achieved revenue and the operating cost of the aircraft.

Figure 6 shows the maximum increase in aircraft cost that can be justified for design payload increases of 5,000 lb and 10,000 lb at various mean projected payloads.

It will be seen from Figure 6, that no allowance for payload increase is available for operations anticipating up to 50,000 lb mean payload or approximately 80% load factor. Above this load factor a payload increase would be justified; however, the price that could be paid for such an increase is considerably less than could be paid for an increase in usable volume.


### ACKNOWLEDGEMENT

The authors would like to take this opportunity to thank the various airlines who contributed their views and criticisms to this paper. Particular thanks are extended to Mr. Frank Kolk, Assistant Vice-President, Equipment Research and Development, American Airlines, since it was at his suggestion that this approach to cargo aircraft design volume was developed.


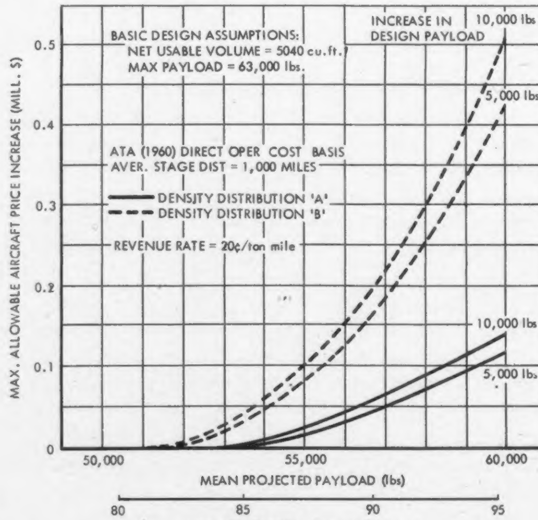


**Figure 6**
**Maximum allowable aircraft price (increase vs payload increase design)**

# APPENDIX

**EFFECT OF AIRCRAFT VOLUME INCREASE ON COST AND REVENUE**

In the foregoing analysis it was pointed out that the feasibility of any volume increase on the basic aircraft will depend on the additional revenue that can be earned by the increased volume version.

If the increase in operating costs resulting from increased volume does not exceed the gain in revènue that can be achieved over the expected life of the aircraft, the operator could probably afford the proposed volume increase in his particular operation. Obviously, there must also be some margin for increased profit applied in such an analysis, since there would be no point to just breaking even on the operation.

The difference in operating cost will be largely dependent on the increase in the aircraft price, and it can be assumed that only the relevant direct operating cost elements are affected. These costs are insurance, depreciation and aircraft maintenance.

Using an established, direct operating cost calculation method[3], an analysis can be developed whereby the maximum allowable aircraft price increase can be derived for any particular operating requirements.

Let:

$\Delta W_a$ = increase in achieved payload (tons) resulting from proposed volume increase
$R_r$ = revenue rate (\$/ton mile)
$D_a$ = depreciation period (years)
$U$ = utilization (hours/year)
$V_b$ = average block speed (mph)
$\Delta R$ = total additional revenue (\$) achieved over the expected life of the aircraft.

Then,

$$\Delta R = (\Delta W_a)(V_b)(U)(D_a)(R_r) \tag{1}$$

The increase in the direct operating cost over the expected life of the aircraft will be found to have the equation

$$\Delta C_d = K_1(\Delta C_t) + K_2 \tag{2}$$

where,

$\Delta C_d$ = increase in direct operating cost (\$) over the aircraft life
$\Delta C_t$ = increase in aircraft price (\$)

$K_1$ and $K_2$ are the factors determined by depreciation, insurance and maintenance.

The amount that an operator can economically invest out of the total additional revenue anticipated by a volume increase will be modified by such factors as the taxes payable on earnings, interest on investment and the expected profit.

These factors can be considered as additional expenses which must be covered by the increased revenue, therefore

$$\Delta C_d + I_r + P_r + T_r = \Delta R \tag{3}$$

where,

$I_r$ = interest on investment (\$)
$P_r$ = profit or return on investment (\$)
$T_r$ = taxes payable on earnings (\$)

The maximum, allowable aircraft price increase can be obtained by solving Eqs. (2) and (3) for $\Delta C_t$ giving

$$\Delta C_t = (\Delta R - I_r - P_r - T_r - K_2)/K_1 \tag{4}$$

A similar analysis can be applied when the design payload is being changed alone or in conjunction with the design volume.

With a change in the basic volume or payload, the performance of the aircraft will be affected to some degree. To obtain qualitative results for this analysis, the effect of aircraft performance was not considered, since the variation in performance was relatively insignificant for the small variations of volume or payload considered. In the final analysis, however, when the economic feasibility of the design change is indicated, the full effect on all aspects of the aircraft performance must be incorporated in the analysis.

## REFERENCES


(1) Bickner, R. E. — *Cargo Density and Airlift*, The Rand Corporation, January 14, 1957.

(2) Feller, W. — *An Introduction to Probability Theory and its Applications*, John Wiley and Sons Inc., 1959.

(3) *Standard Method of Estimating Comparative Direct Operating Costs of Transport Airplanes*, Air Transport Association of America, 1960.

CANADIAN AERONAUTICAL INSTITUTE

# MANUFACTURE AND TESTING OF BLACK BRANT ENGINES†

**by I. R. Cameron,* A.F.C.A.I.**

***Canadian Armament Research and Development Establishment***

SUMMARY

The Canadian rocket propulsion programme has been an integrated programme including ingredient development, process engineering, rocket engine static testing and flight evaluation of test vehicles. Several synthetic elastomeric polymers have been developed and evaluated in various size engines. A remotely controlled, oxidizer grinding and handling system has been engineered and installed. A unique mixing and casting system has been devised and is in use; casting pots have been eliminated by this system which is also remotely operated. Facilities for temperature conditioning and statically firing large solid rocket engines have been built at CARDE and a fixed azimuth, inclined launcher has been installed at Fort Churchill. Several 17 inch diameter Black Brant vehicles have been fired from this launcher with very satisfactory engine and vehicle performance.

**INTRODUCTION**

The Canadian rocket propulsion programme was initiated as a major Defence Research Board effort in 1956. This research would contribute to the defence programme of applied research, produce a group of experts in this field who could assist in weapon systems studies with the Armed Services, and provide a limited production facility for rocket propellants in Canada so that early small scale requirements for Canadian produced missiles could be economically met. Larger scale production would be met by Canadian Arsenals Limited or other industrial sources.

The solid rocket engine differs from the liquid engine primarily in having all the fuel and oxidizer in the combustion chamber, resulting in a much larger combustion chamber which must be designed to withstand the chamber pressure. This design feature has, for many years, limited the mass fraction of propellant in the solid rockets and made them relatively inefficient. However, recent engineering advances in the design of high strength steel cases and improvements in the physical properties of propellants have made possible great improvement in over-all performance, and the two types of engine are now competitive.

The outstanding improvement in the performance of solid propellant rocket engines in recent years has been the development of case-bonded grains in contrast to the free standing grains previously used. The loose-filled grain is fabricated outside the rocket engine case and is usually inhibited on the outside surface so that burning occurs only on the inner surface. It is then necessary to support the grain mechanically within the case to withstand the various accelerations to which it is subjected during and after launch. In addition, hot gases come in contact with the walls of the case. The net result is a heavy case and considerable weight in the form of ancillary hardware. With the case-bonded propellant engine, the outer surface of the propellant is bonded to the case which is thus kept cool until the instant of burn-out, allowing a considerable weight reduction in the case. Another advantage is that the propellant is supported over the entire inner surface of the case and the entire load during acceleration need not be supported at the rear end as with the free standing grain. In view of these considerations, the Canadian programme was confined to case-bondable propellants which could be cast directly in the case.

**CARDE PROPULSION PROGRAMME**

The development of high performance composite rocket propellants at CARDE has been channelled to meet two main objectives for the Armed Services. These are serviceability in the range −65° to +160°F with emphasis on the low temperatures experienced in the Canadian Northland, and immediate firing readiness in the larger rocket engines. These objectives must not be gained at the expense of ballistic performance, since poor longitudinal acceleration capability restricts launching accuracy. Any loss in specific impulse leads to a large increase in all up missile weight; and, since the propellant charges for rockets are considerably larger than those for guns, there is a definite requirement to use ingredients which are inexpensive and indigenous to Canada.

A by-product of the programme has been economically priced rockets for Canadian upper atmosphere studies. The 17 inch diameter vehicle, the Black Brant I, designed as a propellant test vehicle, is being used for upper atmosphere studies at 50 miles. A high altitude vehicle using the same engine case, the Black Brant II, has been designed with lighter components

†Paper read at the Joint I.A.S./C.A.I. Meeting in Montreal on the 17th October, 1960.

*Superintendent, Propulsion Wing

and a longer burning time engine. The Black Brant II version will be launched at the Fort Churchill Rocket Range to test the propellant and the external ballistics of the vehicle. It should reach an altitude of 75 miles with a 100 lb payload.

Increasing the specific impulse of the propellant is not difficult below certain thermodynamic limits. However, high specific impulse is normally associated with fast burning rate. Hence the problem is to change the burning rate with catalysts without appreciably decreasing the propellant specific impulse.

The other engine area is the use of higher strength components in the case, and better insulants in the case and nozzle to control the high combustion chamber flame temperatures, 3000° to 4000°K.

$$5460°R = 5000°F = 2760°C = 3033°K.$$

**Engine casing development**

The steel engine case has been contracted out to commercial firms working to CARDE specification, since adequate in-house facilities for forming, welding and heat treating the thin-walled cases are not available. However, by following the state of the art and modifying the CARDE specification accordingly, minimum weight cases are obtained.

The present 17 inch diameter case has 0.104 to 0.116 inch wall thickness with the over-all case bow and ovality limited to $\pm$ 0.20 inches. The centre of gravity of the flight engine is also restricted to $\pm$ 1.0 inch from the nominal value. Smaller case can be deep drawn but, for this size and larger, rolling and Argon butt welding are preferred. Forged end caps are machined and welded to the welded cylindrical sections. Heat treatment is used to bring the steel up to near maximum strength. Finally, all the welds are x-rayed and the case is proof pressure tested. Welding of thinner sheets, 0.075 and 0.060 inches, is being investigated and higher tensile sheets are being considered, all to reduce the case weight without reducing its performance. Steel ribbon winding and fibre glass cases are being investigated by commercial firms and CARDE will be testing some of these products.

Besides the actual engine case, there are a number of insulating and restricting layers of filled plastic in a rocket engine. Also a nozzle is required that will not change its size or shape during the burning time of the engine. In these areas, the CARDE researchers are actively engaged and have shown definite improvements. The CARDE designed Black Brant I nozzle weighs 43 lb compared with 70 lb for a corresponding size, commercially produced nozzle.

The wall restrictor serves two purposes, both as a heat restrictor to keep aerodynamic heating from warming the propellant hence weakening the bond, and at burn-out this layer keeps the hot chamber gases from burning a hole through the thin wall case. The wall restrictor must also act as a strong bonding agent between the steel wall and the propellant. The end restrictors inhibit the end burning of the propellant, and prevent the hot gases from getting between the wall and the propellant. Failure of these restrictors generally means a burst case and, with a flight vehicle, break-up of the complete vehicle during the initial flight stage with complete loss of experiment or objective. Development of restrictors that have good insulation properties to reduce the actual thickness required, and a good bond over the service temperature range, is a continuing problem since compatibility with the fuel polymer is also required.

The CARDE nozzles presently in use are 4130 steel for body and expansion cone with a graphite insert in the throat. Metal surfaces exposed to the hot propellant gases are oversprayed with 0.005 inch ceramic. Sufficient steel to act as a heat sink to maintain the surface temperature below 500°F has been found satisfactory. Plastic expansion cones and complete plastic nozzles are being developed to further reduce the weight in this rear position where it has a large effect on the centre of longitudinal inertia.

**Propellant development**

It was decided not to use the familiar family of propellants based on nitrocellulose and nitroglycerine, since it was considered that they possessed limitations which would make it extremely difficult to meet some of the requirements. Attention was therefore concentrated on propellants based on a solid crystalline oxidizer and an organic polymerizable binder. The choice of a convenient oxidizer is limited to ammonium nitrate, ammonium perchlorate or potassium perchlorate. For several reasons ammonium perchlorate at 40c per lb was selected. To achieve satisfactory performance, it is necessary to use 70% to 80% of this oxidizer with 20% to 30% of a fuel based on carbon, hydrogen, oxygen and nitrogen. If the propellant is to be castable, the choice of binder or fuel is further limited to polymerizable liquids, and care must be taken to use the optimum oxidizer particle size distribution.

The binder or gum stock selected for the initial CARDE work was based on polyurethane rubbers. The rubbery nature of the cured material over a wide temperature range insured that the stresses developed during temperature cycles could be kept to a minimum. Research at CARDE has led to the satisfactory development of binders which have elastic properties superior to those in service use. The vital ingredient is a high molecular weight synthetic triol which was pioneered in Canada. New co-polymer units which have a very low brittle point are also being developed. To demonstrate the need for very elastic material, a comparison of the physical properties of the cured binder or gum stock and those of the 75% ammonium perchlorate filled propellant has been tabulated:

| *Property* | *Cured binder* | *Cured propellant* |
|---|---|---|
| % elongation to max. stress | 300-400 | 15-20 |
| Max. stress, psi | 300 | 60-150 |
| Young's modulus, psi | 300-600 | 5000-10,000 |
| Brittle point, °C | –85 | –60 |

**Propellant processing**

Briefly, in the CARDE cast composite process, the oxidizer is ground to a fine grist and air lifted to the propellant mixer. The rubber binder is added in the ratio of one part to three of crystalline oxidizer, and the batch is blended to a uniform slurry and degassed

for 20 to 40 minutes. The engine case is degreased, coated with a bonding layer on the inside and positioned with its mandrel in the casting bell. The mixer is attached to the engine which is then evacuated to 3 mm Hg and the mixer is gravity dumped. After hot curing for several days, the central mandrel is removed, the nozzle and igniter attached and the engine is ready to fire. A dynamic flight vehicle requires additional check-out stages, including mechanical alignment of the fins, nose and telemetry package.

In the processing engineering, CARDE has developed three features that have not been used previously in propellant or high explosive processing: first, totally enclosed air lift system of grinding and blending the crystalline oxidizer, second, positive glands for mixers, which prevent contamination and possible explosions in a vacuum mixing machine and, third, transportation of the loaded mixer to the large rocket engine case and vacuum coupling by remote control. In other locations, the mix is transported in transfer buggies from the mixer to the engine location; this procedure increases the hazard of contamination and increases the possibility of entrapping air bubbles.

**Preparation of oxidizer**

The process was designed with the object of providing a discrete, free-flowing, surface-dried blend of ground and unground ammonium perchlorate, which should remain in the uncaked state with carefully controlled particle size distribution for periods of six weeks or more. The process was to be made as dust-free as possible from the time the perchlorate was removed from the original containers until it was fed into the propellant mixer. Since the material must be transferred first from its original containers to other equipment for deagglomerating, grinding, blending and storage, and back again from storage for final propellant mixing, it was clear that the system could not be made entirely dust-free. But with all open transfers made in one small room, the rest of the system could be designed as a dust-tight unit.

Ammonium perchlorate is brought, in its original drums, to the central transfer room. The contents of the drums are dumped, individually, into a hopper, which is lifted up a wall to deposit its load automatically into an upper level chute, which projects through the wall and directly through the lid of a spiral ribbon blender capable of processing 2,000 lb per load. After loading, the anti-caking agent is added and the blender blades placed in motion. The temperature is controlled to allow a rise to 180°F in 4 hours, in which time all of the original aggregates have disappeared and the tricalcium phosphate has been reduced in particle size by the action of the tumbling ammonium perchlorate to the point where the ammonium perchlorate, left in the open atmosphere, does not re-cake.

After the deagglomerating period, the hot perchlorate is metered through the bottom part of the blender into a horizontal duct, having at one end an air-heating device which will provide 1000 cfm of air at 200°F from an air supply at an ambient temperature of −25°F. The hot air transfers the perchlorate to a dust collector, which is situated at a horizontal distance of about 50 ft and a height of 18 ft from the blender. The product is fed from the collector through a rotary air lock fitted with a diversion gate, so that the product may be dispensed proportionally into two ribbon blenders. Under these conditions the ammonium perchlorate arrives surface dry at the collector at a rate of about 700 lb per hour. One of the blenders under the collector is capable of holding 2000 lb and receives 65% of the perchlorate before the remaining 35% is diverted to the other blender. The latter blender is in turn positioned directly over three grinders, connected by ducting. They are a micro-pulverizer, a micro-atomizer and a micro-Bud, and are capable of providing any required particle size. The arragnement is shown in Figure 1.

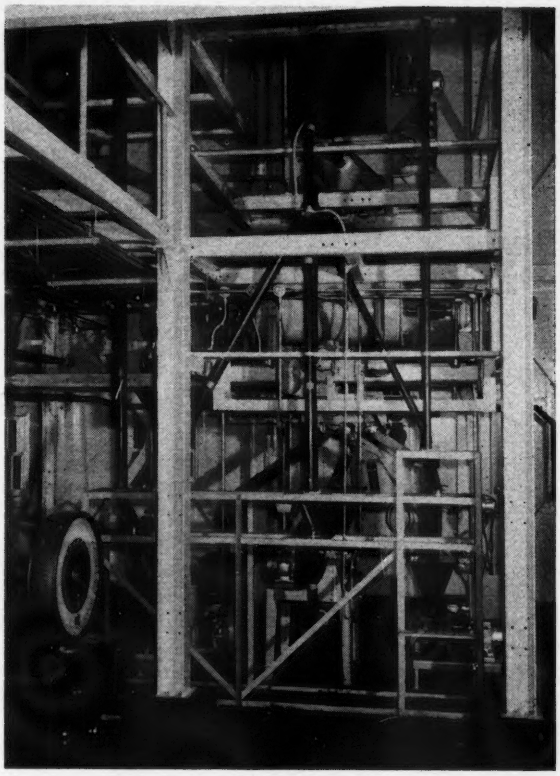

**Figure 1**
**Oxidizer grinding system**

After the proportions to be passed through each grinder are determined, the amounts are metered in turn through the appropriate grinder and are once more picked up at the outlets in an air stream and conveyed via the same dust collector as previously used, this time to be deposited in the blender containing the unground 65% of the perchlorate. After blending, a sample is taken, through a dust-tight sampling device in the blender, and analyses performed. If the control limits are not met, the appropriate grist is added. The finished batch is transferred by means of a duct from the dumping port of the blender through the wall and into the transfer room where it is bagged and weighed.

Provision has been made in the facility for individual experimental grinds to be handled. The product of each grinder may be directed either to the

original collector as described above or to an individual collector, under each of which is a small ribbon blender in lieu of a hopper or bin. A separate but smaller capacity system, comprising a micro-pulverizer and blenders, has been installed to process other oxidizers such as potassium perchlorate. A secondary collector connected in line with the other five primary collectors has been installed as protection in case of a bag break or leak which would otherwise contaminate the area. This collector is also fitted with an intake pipe, 1.5 inches in diameter, which is strung throughout the building with bung openings at strategic locations. For small spills this may be used as a vacuum cleaner by pulling the bung and inserting a flexible hose and fitting.

The ammonium perchlorate is subject to "Running Blend" and the important control tests are particle size distribution, total moisture and surface moisture. Tricalcium phosphate, the anti-caking agent, is dried for 48 hours at 170°F before being added to the system, where its concentration is determined by analysis. Particle size distribution is determined by sieve and micromerograph analyses. Total and surface moisture are determined by titrating with Karl Fischer reagent. In the first case a 15 to 20 gram sample is dissolved in 100 ml of 3 to 1 pyridine/methanol mixture and in the latter a similar amount is added to a saturated solution of ammonium perchlorate in methanol. The upper limits are 0.04% total moisture and 0.02% surface moisture.

After storage, the various running blend increments are returned to the original room where the drums were first emptied. The five increments are introduced to the first blender through the hopper as before and blended together. The feed of this blender is now diverted to another pipe, having the same hot air source at one terminal but a dust collector in the final mixing building at its other extreme. The distance is about 70 ft in the horizontal direction and 20 ft difference in height. The rotary air lock of this collector is connected with a telescoping duct which enters directly into the loading port of the final mixer.

#### Propellant casting and curing

The polyurethane binder is prepared in several stages. A prepolymer adduct is synthesized from the high molecular weight triol and tolylene diisocyanate. The final polymer is made in the propellant mixer with the prepolymer, the main diol and the remainder of the isocyanate. Since the organic isocyanate will readily react with water, all ingredients have been dried and maintained under an inert atmosphere. Pfaudler glass-lined pots are used to contain and prepare the binder (Figure 2).

The engine case and all its casting attachments are degreased in a vapour phase trichlorethylene bath. The vertical bath is steam heated with cold water coils near the top of the degreaser to condense the rising vapour and prevent overflow of the trichlorethylene into the room. The large degreaser is 26 ft deep to accommodate complete large engine cases.

After degreasing, the case is internally coated with a heat barrier restrictor and bonding agent. This is a mica filled polyurethane which bonds well to the steel wall and to the propellant. The unpolymerized agent is poured into the long tray. The tray is slid inside the engine case and aligned with the engine. While the engine case is rotated at 20 rpm, the tray is tipped to plaster the bonding agent over the inner surface of the engine case. A brush may be used to smooth out the material before the engine is spun at 80 rpm and the coating cured by banks of external infra-red lamps and an inner steam convector.

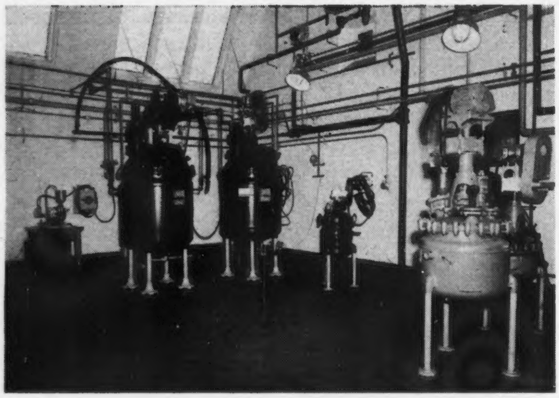

**Figure 2**
**Polyurethane prepolymer preparation**

The large scale horizontal propellant mixer (Figure 3) was manufactured to a CARDE design and incorporates many unique features. The mixer has its own transfer wheels on a 54 inch track and may hold 3000 lb of propellant. Empty, the mixer weighs 10 tons. The drive shaft runs completely through the mixer with the main mixer motor engaged at one end and, at the casting position, a smaller low speed motor engages the other end of the shaft to rotate the mixer blades during casting.

In normal double base propellant, sigma blade kneaders, simple external glands or no glands are employed. Supports to prevent end play of sigma blades are used. For self curing liquids, a positive seal is mandatory especially when vacuum mixing is required. The CARDE designed gland has teflon inserts as the main barrier with grease-free felt as the advance barrier. These felts are changed after each mix. However, if the felt is not completely penetrated, the teflon gland is not opened.

Another main feature of this mixer is the dumping device which engages the engine case at its casting site, forms a vacuum, seals and dumps the propellant charge to a predetermined depth in the case. Basically the dump valve is a rubber bung which is moved hydraulically to permit the gravity casting of the unpolymerized propellant. The two forks lift the engine case adaptor over the O-ring seal to form the vacuum joint. An adjustable siphoning device removes any propellant that fills the engine above the prescribed height.

Internally the mixer has a double ribbon blade to blend the crystalline oxidizer and liquid binders. The centre feeding ribbon blades feed the propellant towards the centrally located dumping valve. This type

of machine can effectively mix batches from one-quarter to full capacity of the tub.

After the propellant is cast into the propellant case, the vacuum is released and the mixer withdrawn for solvent cleaning. The engine case is capped and the hot air is circulated between the casting bell and the engine case to cure the propellant at programmed temperatures up to 122°F. After a total cure time of 72 hours, the heating is removed and the engine permitted to cool. The casting mandrel is withdrawn and the internal surface is examined minutely for cracks, breaks, air bubbles and non-adhesion to restrictors. Shore hardness is also measured to check the propellant surface hardness. Laboratory samples were taken at the time of mixing and these have been analyzed; cured specimens are tested for tensile properties and brittle point.

To minimize the hazard to personnel, the oxidizer grinding, blending and transfer are handled from a barricaded control console. This console is also used to control all the propellant mixing operations from the addition of the ingredients into the mixer to cleaning and removal of the cold cured engine.

### ENGINE STATIC TEST AND EVALUATION

When the engine is to be used in a static test, thrust and pressure gauges are installed along with the igniter at the head end, and the nozzle is screwed or bolted to the other end. The engine is then mounted on a rail thrust car, spring loaded against the thrust plate and fired.

In practice the laboratory formulations are first cast into work horse engines 8 inches in diameter and 40 inches long. Later, 80 inch long engines of the same diameter are used to determine erosive burning rates. Only when the burning rates and specific impulse of the propellant are known, are 17 inch Black Brant engines filled.

Both an igniter and nozzle were required for the Black Brant and these were also developed during this same period. The igniter consists of a combination of SR 371C powder (60g) and SR 371 pellets (300g) in a proportion which gives low (16 psi) and equal pressure rises at head and nozzle ends of the engine conduit. This igniter is initiated by four electric F53 (ICI) squibs in series-parallel. In the Black Brant vehicles, the nozzle is completely shrouded in a light alloy casting which supports the fins. The throat and entry section of the nozzle is a graphite insert in steel. The 5 to 1 expansion cone is a continuation of the steel section, and the internal surface of the nozzle is oversprayed with aluminum oxide ceramic.

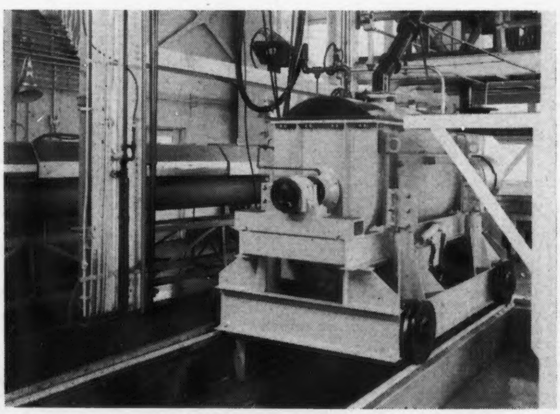

**Figure 3**
**Large scale horizontal propellant mixer**

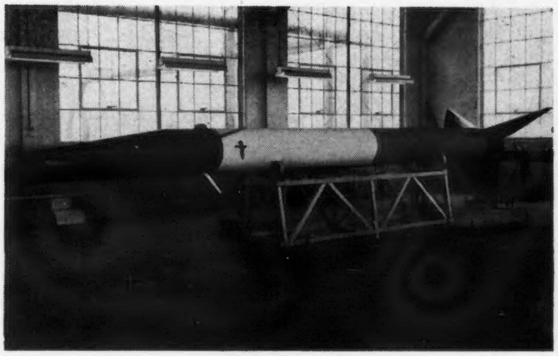

**Figure 4**
**Mechanical alignment of Black Brant I**

The present propellant formulation was finalized in October 1958 and the first Black Brant engine was fired statically in February 1959. Other firings were made during the spring and the Black Brant engine parameters were evaluated at 13°, 70° and 120°F.

### TEST VEHICLE

In 1956, an engine case, 17 inches in diameter and 17 ft long, was available from the Bristol Aircraft Company and it met the requirements for static firings at CARDE. In the spring of 1957, the Canadian branch of this firm, Bristol Aero-Industries of Winnipeg, was awarded a contract to build a propulsion test vehicle around the 17 inch engine. This vehicle (Figure 4) was 24 ft in length with three telemetry antennae forward and three fixed cropped delta, 39.1 inch semispan fins at the rear. The 16° included angle nose and instrument section had a total length of 7 ft, and had an integral frame and skin with space for several hundred pounds of instruments. The first vehicles were delivered in January 1959 with other deliveries at monthly intervals.

For propellant studies, relatively simple telemetry was required to send back data on engine pressure and engine case temperatures. A standard 30 by 30 PDM-FM (pulse duration modulated-frequency modulated carrier) system having 28 active channels was assembled. Accelerometers and skin thermistors were added to supply additional data on the vehicle performance and on the effects of flying at a high Mach number through the lower atmosphere. A radar beacon was installed in the nose to aid tracking of the vehicle throughout its trajectory, to evaluate drag and verify its high altitude potential.

### DYNAMIC LAUNCHING

An inexpensive inclined launcher (Figure 5) was designed in the latter months of 1957. With this de-

sign, the vehicle is carted under the horizontal boom and underslung from three guide rails. The boom and vehicle are then elevated to the launch angle, which may be set between 70° and 82°, and the forward braces are bolted to ground anchors. At launch, the vehicle slides on shoes along the 15 ft length of zero tip-off guide rails and is airborne with a forward velocity of 80 ft/sec and an 8g acceleration.

In the fall of 1958, the inclined launcher was installed at the Fort Churchill Rocket Firing Range some 200 ft south of the IGY Nike-Cajun Assembly Building. The launching direction was approximately due east over Hudson Bay to provide maximum safety, since recovery was not warranted.

In September 1959, the first group of Black Brants were launched, and all flights were successful although complete radar and telemetry data were not obtained.

The first two vehicles were ballasted heavily to insure that a large stability margin would be maintained at Mach 6 and they were fired with an engine temperature of 60°F. The latter two vehicles were lightly ballasted to what was called the minimum telemetry weight and were fired with an engine temperature of 100°F. No evidence of aerodynamic instability was obtained from any of the flights.

The altitude versus range data for the two weights of vehicle have been plotted from the radar tracking data. Time to maximum altitude and time to impact are given in seconds from launch. With a 365 lb nose cone the Black Brant reached an altitude of 56.4 miles and impacted at a range of 136 miles, while with a 254 lb nose cone the Black Brant reached an altitude of 72 miles and impacted at a range of 145 miles. All four vehicles were launched at 70° elevation. With a vertical launcher, these altitudes would be increased to 100 and 115 miles respectively.

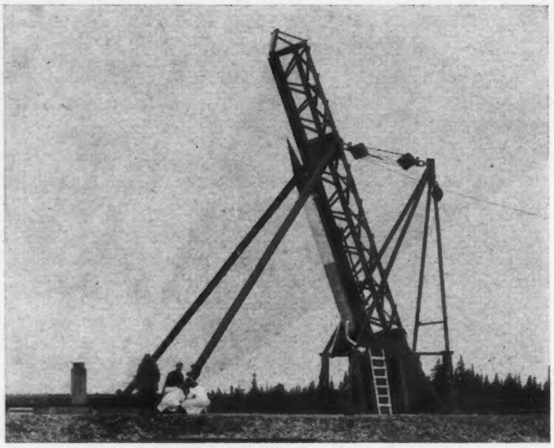

**Figure 5**
**Black Brant I on launcher**

# THE APPLIED SCIENTIST — A NEW MEMBER OF THE ENGINEERING TEAM†

by Dr. G. N. Patterson,* F.C.A.I.

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## INTRODUCTION

Some of the men and women who will be our engineers in the year 2000 A.D. have already begun their training in our universities. A serious consideration of the educational requirements of these future engineers is therefore a matter of great urgency. First, however, we must try to agree on what a modern engineer really is, and then by some kind of extrapolation we hope to visualize his activities and scope in the year 2000 A.D. Finally, we must decide what facilities and curricula are needed now to adequately train such a man.

## MODERN CONCEPT OF THE ENGINEER

It is my view that the engineer is no longer a person but a team — a "foursome" which includes the craftsman, technician, engineer and applied scientist. The roles played by the craftsman and technician are decidedly important but they are outside the scope of my talk. In fact my experience qualifies me to speak only about the engineering scientist and his place on the team.

The general belief that engineering is a profession which is responsible for the judicious application of existing knowledge for the benefit of mankind, and that engineering, development and research are a continuum made up of three separable regimes, must undergo a change. It is true to a certain extent now and should be more so in the future that engineers must design equipment without the complete knowledge needed to undertake the work. In many cases the resulting facility can be regarded only as one stage in a developmental project. To improve the design, special research is needed which often involves the use of the facility itself, and the engineer now requires the co-operation of the applied scientist to complete the job. The engineering scientist is already well established in industry, government and university as an essential member of the engineering team. Today's course of study must take account of the ever-increasing spectrum of activities which the engineering profession embraces and must be based on the inseparability of engineering, development and research.

Let me illustrate these ideas by an experience in the laboratories of the Institute of Aerophysics, University of Toronto. About seven years ago we undertook the design and construction of a low-density wind tunnel for the study of flight in the upper atmosphere, under the sponsorship of the Canadian Defence Research Board and the US Air Force Office of Scientific Research. Our objective was to reproduce on a model the free-molecule flow experienced by satellites. It soon became apparent that the design would involve a considerable knowledge of the mechanics of rarefied gases, most of which belonged in the regime which would be investigated in the tunnel when it was built! Clearly the ultimate design could be reached only by an iterative process involving engineering, development, research, engineering, . . . . That the tunnel was in satisfactory operation some time before the first Sputnik beeped overhead in 1957 was due to the fact that our team included qualified engineers who were in training to become engineering scientists. As a result of our work, wind tunnels of this type have now become standard equipment in a number of laboratories. Many new engineering products of the future will be produced in just this way.

There may be some who doubt that engineering has a special responsibility toward development and research. It may be considered that this area of work should be left to the chemists, mathematicians and physicists. Let me quote from "A Manual on Graduate Study in Engineering", a report published in the *Journal of Engineering Education* in June, 1945, by a committee of the Society for the Promotion of Engineering Education: "New branches of science are developing at an amazing pace within the confines of engineering. Fluid flow, heat transfer, electronics, supersonic aerodynamics, mechanics of stress and of vibrations — these are no longer physics even when physics is broadly defined. Neither can they be defined completely as applications of physics though they use the great body of knowledge that the physicist has accumulated.

"Within engineering itself we see research workers steadily developing these new branches of engineering science. This changing character of engineering, this development from a construction art to a broad productive activity encompassing research, design, and construction, and sustaining within itself the beneficent growth of whole new branches of science, is the vital force of graduate study."

†Paper read at a session on "The Engineer in 2000 A.D." at the Fourth Engineering Education Conference, held by the EIC and ASME in Montreal on the 5th and 6th October, 1960, and is published with their permission.

*Director

The list of engineering science topics given in this quotation was true fifteen years ago. Now we could write out a much longer list which would show that what was a trend in 1945 has now become an established fact. The task of training the engineer for the year 2000 A.D. will not be complete unless the applied scientist is granted full recognition as a member of the engineering team and his educational needs adequately met by engineering faculties in the universities.

**RECENT DEVELOPMENTS IN AEROSPACE ENGINEERING**

Some concept of the qualifications, activities and scope of the engineer in 2000 A.D. can be obtained by a study of the important trends in modern engineering. One can say of engineering in the past that it was primarily concerned with materials and energies largely as they were found in nature. The over-all modern trend is toward the discovery and use of new materials and new sources of energy as a result of large scale research and development. The engineer is increasingly concerned with physical conditions not ordinarily found in nature as we know it. Through his investigations he is developing a higher level of creativity based on the fact that research and development have become an engineering responsibility.

Our idea of the engineer in 2000 A.D. must necessarily be obtained by an extrapolation from modern trends. Undoubtedly the present standard branches of engineering will be well represented in the year 2000 A.D., but one of the most significant of the current trends is the appearance of new branches. A large, fast-growing branch is the field of aerospace engineering. I believe that a study of the modern position of this interesting branch will do much to raise our sights to where they should be in looking forward to 2000 A.D.

We can obtain some appreciation of current progress in aerospace engineering from a list of the research and test vehicles now under development in the USA. Nearly seventy projects on spacecraft, missiles and high speed aircraft can be mentioned. Just to indicate a few of them, the National Aeronautics and Space Administration (NASA) is supervising such projects as Atlas-Able as a deep space probe capable of orbiting a 200 lb payload around the moon, Centaur as a three stage rocket for boosting an 8000 lb payload into orbit at 300 miles altitude, and Mercury as a high-priority program to put an astronaut into orbit at 120 miles altitude and to return him by parachute after three passes around the earth.

The environment of the upper atmosphere and the space beyond presents many new challenges to the aerospace engineer. It is now apparent that efficient design depends on an accurate knowledge of the physical environment. Our understanding of the solar system and interplanetary space undergoes a change every time a new space probe sends back data. Quantitative data are far too scarce at present to permit reliable space vehicle design. We do know that dissociation, ionization and changes of atomic state occur in the upper atmosphere as the result of energy received from the sun. The constituents of the upper atmosphere are likely to be chemically active – for example, such unstable compounds as $O_3$ and NO will attack organic materials and some common metals. We know that a satellite is surrounded by an ionized sheath of particles which adversely affects radio transmission. Such effects as sputtering due to the high speed impingement of atoms and molecules on a surface may be a factor for future consideration. The problems produced by low pressure are perhaps more familiar. The absence of conduction, convection and pressure recovery capability place severe limits on vehicle design. Such phenomena as outgassing, volatilization and arcing require attention. Low pressure effects on the properties of structural materials may be a serious problem. Although the temperature in the upper atmosphere probably exceeds 1500°K, the temperature of a vehicle can be kept reasonable by proper use of reflectivity and emissivity. Perhaps more significant is the extremely low temperature of outer space which has an equivalent black-body temperature of 4°K. The effects of very low temperature can be good and bad. For example the tensile strength of many materials may be two or three times greater at cryogenic temperatures. On the other hand embrittlement of some metallic substances including carbon steel introduces new problems. A new difficulty is the superconductivity which occurs between 0°K and 18°K which may restrict the use of some materials. Corpuscular radiation remains a serious problem. In addition to its capability for producing a wide range of atomic changes of both a physical and a chemical nature, low-energy particle radiation can raise the thermal level of impinged materials while high-energy (cosmic) particles can be stopped only by at least a six inch thickness of steel, an impossible requirement from a design point of view. Fortunately the density of cosmic rays is very low and it may be reasonable to omit protection. With regard to micrometeorite dust and meteorites, existing data indicate that penetration of a space vehicle will occur on the average once in five years. Destruction by large meteors might occur only once in a million years.

A good example of the ever-widening range of design requirements which face the engineer is found in the field of propulsion where the vehicle may be undersea, in the atmosphere or out in space. Chemical, nuclear and plasma propulsive systems are under development. The parallel development of liquid- and solid-fueled rockets is being extended into the large booster field. The former continue to have a higher specific impulse and the current trend toward the use of hydrogen promises still further improvement in performance. The requirement for restartable motors to assist in landing and re-entry, and to provide orbital and attitude corrections appears most likely to be met by liquid-fueled rockets. On the other hand the modern tendency to large boosters (1,000,000 lb thrust or more) seems to favour the solid-fueled rocket which

can be assembled on-site and which has fewer storage problems. The use of hydrogen as a working fluid in a heat transfer reactor has led to progress in the development of nuclear propulsion. An interesting possibility is the use of nuclear charges fired from a gun which could develop millions of pounds of thrust. The new, rapidly-accelerating field of magnetogasdynamics illustrates the benefits of combining two previously separate disciplines of science. The plasma space engine is emerging as one of the first applications of this new subject.

The creation of new materials is of considerable interest to the engineer, and only a close contact with the results of research will keep him abreast of modern developments which amount to a genuine revolution in this field. The close control of constituents and the use of rare earth metals give promise of a considerable improvement in steel alloys. Outstanding progress has been made with the so-called "exotic" materials. Beryllides have been found to have good strength/weight ratio at high temperatures, high thermal conductivity and oxidation resistance. Refractory metals (e.g. tungsten) can be used either for basic structure or as a heat shield. A new departure in materials technology involves the use of "whiskers" – tiny hairs grown on the surface of some metals and plastics which are fantastically strong. The strength of copper was increased four-fold by the addition of tungsten fibres.

This list of modern marvels in aerospace engineering may seem to be somewhat ethereal to those of you who regard yourselves as practical, down-to-earth engineers. Nevertheless we must recall the profound effect that the aircraft industry has had in introducing new techniques and materials into other industries. It is a fact that what blesses one branch of engineering must surely bless all others. Furthermore we are all deeply aware of the ever more serious need for rapid and impressive progress in defence research, development and production. The aerospace engineer merely typifies the fact that engineering in general is in the forefront of the race to maintain at least technical parity with the East. I am sorry to say that I believe that those prophets who forecast the disappearance of this competition by 2000 A.D. are just whistling in the dark. We have a serious responsibility to turn out adequately trained engineers and scientists to ensure a superior defence strength.

**THE ENGINEER IN 2000 A.D.**

In the preceding discussion I have outlined only a few ideas which might help us to extrapolate to the year 2000 A.D. Perhaps you will agree with me that the days of the handbook engineer and his empiricist outlook are numbered. Nor is textbook science enough. The modern engineer must have a strong scientific outlook and be quite familiar with the latest developments in his field. In particular he must be able to understand and coöperate effectively with his new partner, the engineering scientist. Modern development clearly verifies that the applied scientist is an essential member of the engineering team. He must appreciate the importance of development and be willing to assist. He must be responsible for the fundamental contributions necessary to complete the underlying knowledge needed to bring a project to a successful conclusion. While the emergency of the moment may create useful members of the engineering team out of chemists, mathematicians or physicists, nevertheless, as a matter of basic educational policy, the applied scientist must be trained in the faculties of engineering.

In the universities we like to feel that we are doing the most essential job in the engineering profession. After all, what product has the potentiality of the trained human being? And since the engineer in 2000 A.D. will also be a human being, can we leave the moral and spiritual out of our considerations? The spiritual is for conscience and experience and I do not have the temerity to trespass on this subject, but surely we can say about the effective engineer in 2000 A.D. that his equipment will not include a licentious disposition. Because of his ability to co-operate with others he will be respected in his community; perhaps he will even be public-spirited. Who knows, perhaps by 2000 A.D. we will elect a sufficient number of engineers to the Canadian parliament to give the engineering profession the representation it deserves and which good government needs.

**EDUCATIONAL REQUIREMENTS**

If you will permit me to continue with my discussion of the aerospace engineer, now that we have some idea of his present and future activities, the most urgent problem is to make available the educational facilities which will produce such a man. How do we provide an undergraduate with such a wide coverage of fundamentals and yet remain within a particular engineering specialty? The answer is that we cannot. We will be wise if we acknowledge this fact and organize our undergraduate engineering curriculum to provide a broad basic understanding of the physical sciences. But this suggestion is not new nor should it be confined to aerospace engineering. Twenty years ago a committee of the Society for the Promotion of Engineering Education had this to recommend[a]: "Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies. This will require greater efficiency in the use of the student's time to be gained by pruning to the essentials of a sound educational program."

And how do we make room for such changes? Let us refer again to this report: "Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the post-graduate period where it may be pursued with a rigor consistent with preparation for engineering specialization." Let me pursue this further by a quotation from a paper on "The Role of Research in Engineering Education" by Dr. L. V. Berkner, presented to the American Society for Engineering Education

[a]*Aims and Scope of Engineering Curricula,* Journal of Engineering Education, Vol. 30, No. 7, March, 1940.

just a few months ago: "The place for real specialization now is at the level of the advanced degree. Here equipped with a strong mathematical background, and a knowledge of science in mathematical terms, the student can proceed quickly to the formal and sophisticated coverage of the subject of any specialty." But this kind of undergraduate training also provides a suitable beginning for the engineering scientist. Following such an undergraduate course, the modern engineering faculty must be prepared to provide training at the graduate level to complete the education of future engineers (probably leading to the master's degree) and it must also be capable of supervising the advanced work needed to produce the engineering scientist (leading to the master's degree and doctorate).

It is now recognized that the training of the engineering scientist to the doctorate level involves original research on problems that open new doorways for the application of science. To educate the applied scientist the engineering faculty must provide a highly competent staff which not only recognizes the value of research in the teaching activity but which also is regularly contributing new advances in science. Adequate laboratory facilities must be provided and financial inducement to continue his training must be available for the brilliant student. In addition to this we must have a serious appreciation on the part of the university administration of the need to promote graduate studies in engineering. We have grown out of the phase when graduate work was the result of catering to the whims of capable staff members who needed research funds and research assistants to keep them happy. There is an urgent and important job to be done at the graduate level and it must be organized to the best of our ability.

I think we will all agree that, in some areas of engineering at least, the research institute has come to the campus to stay. In aerospace engineering it is simply a fact that the research institute can undertake an investigation at a lower cost than the isolated professor and his group of assistants. The institute provides the cross-stimulus between staff members working in related fields of science which is so necessary for productive research. The permanence and reputation of an institute attracts research contracts and grants naturally. It is my experience that provided the university accepts full financial responsibility for its teaching activities, the engineering research institute can otherwise be made self-supporting through an effective research program. With proper backing from the university administration and from the agencies which supply funds, the research institute provides the right atmosphere to create those Ph.D.'s in engineering science who will be our leaders of tomorrow.

In setting up a training program for the engineering doctorate, the university is faced with severe problems in the field of finance, personnel, facilities and management. The situation is made orders of magnitude more difficult by the number of engineering specialties at the doctorate level, which now number over one hundred. We must be realistic and plan our engineering research institutes, or their equivalent, so that somewhere on this continent the graduate student can take a Ph.D. in the engineering science specialty of his choice in an internationally-known laboratory. At the present time we are nowhere near having sufficient research centres for training the engineering scientist. Perhaps some of you who read this could assist in instituting a study of this problem in the hope that sufficient training centres may exist by 2000 A.D. A makeshift arrangement with industry for off-campus facilities leads to reduced contact between the university and the student just when it is most needed. Despite the growth of this kind of thing, in my opinion it does not provide an adequate answer. Furthermore, universities which try to set up one research organization for all branches of engineering science are not providing a realistic answer. This kind of arrangement is the result of a lack of appreciation of the large-scale requirements of the future and of the need for an adequate staff in a given area to induce the highly important ingredient of cross-stimulation. Sooner or later such organizations must emphasize some areas and abandon others in order to remain competitive for grants and contracts with other specialized institutes. The distribution of institutes among universities on this continent must be well planned to avoid useless overlap.

You will detect a note of urgency in the preceding remarks. Indeed there is. We graduate about 1,000 doctors in engineering science each year on this continent, a number which does not even supply the replacements needed due to retirements and changes to other positions. The subject of the shortage of engineers and scientists is beyond the scope of this paper. It is already well treated in the book on "The Next Hundred Years" by Brown, Bonner and Weir. It is sufficient to mention their conclusion that the supply will be less than half the demand by 2000 A.D. In addition to this we have another problem. In the USA the first-year enrolment in engineering courses has shown decreases of 11.1% and 3.4% during the past two academic years when in fact the demand required substantial increases. Perhaps this is temporary. Nevertheless, an analysis has shown that these decreases have been partly due to a genuine shift of interest from engineering to science. And now at the graduate level our effort at training specialists in engineering science is far below the requirement. I have already shown that adapting our applied scientist into the engineering team from the ranks of Ph.D.'s in mathematics, physics and chemistry may bring temporary relief but it is not the best answer because the man we need is just a different kind of specialist. Finally, let me quote again from Dr. Berkner's address: "In my opinion, engineering must cover all of technology — all of the applications of science to human need — or else engineering will fade into a minor obscurity. The time has come when engineering education must fish or cut bait. Unless engineering education faces its responsibilities, other means of training for an adequate number of applied scientists at the graduate level must be found."

## CONCLUSION

Let me present my conclusions in the form of a recommendation: a study should be made of the educational requirements of the engineering scientist and the methods for meeting them with the following objectives:

(a) To acquaint engineering faculties with the need for planned, large-scale educational facilities in specialized areas at the graduate level and instill a greater recognition of the importance of the research institute as a division of its activities;

(b) To improve the method of financing specialized engineering research institutes on the campus so that space and facilities, internationally-known scientists and teachers, and adequate student support may be available;

(c) To evolve an over-all plan of research institutes for this continent so that all modern disciplines of engineering science are adequately covered; and

(d) To determine the kind of course the engineering scientist needs as distinct from that of the Ph.D. in the pure physical sciences and to suggest a basis for accreditation by the appropriate authorities.

# FILM LIST

The Institute is engaged in the preparation of a concise List of aviation films for the use of its Branches and Sections and by other organizations interested in obtaining films on aeronautical subjects. The work is being undertaken in collaboration with the Air Industries and Transport Association and the Canadian Owners and Pilots Association and, therefore, the List will include films on flying training, meteorology, and other aspects of aviation, as well as engineering.

Several lists of aviation films are already available, but they include a great deal of obsolete material and they probably omit many interesting technical films, held by research organizations and the like, which might be procurable by special arrangement for showing to restricted and qualified audiences. Furthermore, it is not possible to classify films intelligently from the titles and brief descriptions usually given in these lists. Consequently any consolidation of the existing lists would contribute nothing; the proposed List must be based upon first-hand reports.

Since it is clearly impractical to set up a Selection Committee to review, assess and classify all the films which might be of interest, all members of the Institute are asked to cooperate in this work. Any member having personal knowledge of a film which, in his opinion, would be instructive or of current interest to an aviation audience is asked to send particulars to the Secretary of the Institute.

To ensure that the particulars reported are those needed in the listing, a special report form or "check sheet" has been prepared; these forms are available from the Chairmen of Branch Programmes Committees and from C.A.I. Headquarters.

CANADIAN AERONAUTICAL INSTITUTE

## SCHEDULED NASA LAUNCHINGS OF SCIENTIFIC SOUNDING ROCKETS, SATELLITES, AND ROCKET PROBES

***Calendar Year 1961-1963***

*The tabulation appearing on this page and overleaf was submitted by Mr. R. M. Sellens, M.C.A.I., in November 1960. It has been checked and brought up to date (December 1960) by the National Aeronautics and Space Administration, and can be regarded as reliable. — Sec.*

Scheduling Date: December 1960

| Vehicle | Payload Weight (lb) | Number of Launchings | Mission |
|---|---|---|---|
| SCIENTIFIC SOUNDING ROCKETS | | | |
| | | | Calendar Year 1961[b] |
| Aerobee 150A; Nike Cajun; Argo D-4; and others in smaller quantities | 20–150 | A total of 90 launchings are planned for calendar year 1961 carrying experiments in the various scientific areas listed under "Mission"[a]. | Studies of the properties of the atmosphere; ionospherics, energetic particles; magnetic fields; plasma; micrometeorites; electromagnetic radiation; gravitation and geodesy; solar, stellar, and galactic astronomy. |
| SCIENTIFIC SPACE PROBES[c] | | | |
| | | | Calendar Year 1961 |
| Delta | 75 | 1 | RB Vapor magnetometer space probe (P-14) |
| Scout | 60 | 2 | Electron density probes (P-21, P-21a) |
| Atlas-Agena B | 605 | 2 | Lunar Spacecraft Test Vehicles (Ranger) (P-32, P-33) |
| | | | Calendar Year 1962 |
| Atlas-Agena B | 750 | 3 | Lunar impact–high resolution TV (Ranger) (P-34, P-35, P-36) |
| Scout | 200 | 1 | Recoverable cosmic ray emulsions[d] (P-26) |
| Centaur | 1,050 | 1 | Venus probe[d] (Mariner) (P-37) |
| Centaur | 1,050 | 1 | Planetary Spacecraft Test[d] (Mariner) (P-38) |
| | | | Calendar Year 1963 |
| Centaur | 2,500 | 2 | Lunar soft landing[d] (Surveyor) (P-42, P-43) |
| Centaur | 1,200 | 1 | Planetary Spacecraft Test[d] (Mariner) (P-39) |

[a] Rocket launchings are not firmly scheduled by scientific missions until some weeks or months before actual firings; thus the numerical representation of launchings by scientific categories would represent a partial summary only.

[b] Extent of provisional launching schedule. In the rocket program, no flight planning is undertaken beyond the lead time required for funding.

[c] *Vehicle* test and backup launchings are omitted from this list. *Spacecraft* test launchings are included.

[d] Proposed flight mission; technical development plan for one or more elements of the over-all vehicle are not yet established.

Scheduling Date: December 1960

| Vehicle | Payload Weight (lb) | Number of Launchings | Mission |
|---|---|---|---|
| SCIENTIFIC SATELLITES[e] | | | |
| | | | Calendar Year 1961 |
| Juno II | 85 | 1 | Gamma ray astronomy (S-15) |
| Delta | 83 | 1 | Energetic particles satellite (S-3) |
| Delta | 400 | 1 | Orbiting Solar Observatory (S-16) |
| Delta | 280 | 1 | TIROS meteorological satellite (A-3) |
| Delta | 350 | 1 | Atmospheric structures (S-6) |
| Scout | 120 | 1 | Micrometeorite puncture hazards (S-55) |
| Juno II | 75 | 1 | Ionosphere Beacon (S-45) |
| | | | Calendar Year 1962 |
| Scout | 150 | 1 | International ionosphere satellite (S-51) |
| Thor-Agena B | 275 | 1 | Swept-frequency topside ionospheric sounder (Canadian) (S-27) |
| Delta | 400 | 1 | Orbiting Solar Observatory (S-16a) |
| Thor-Agena B | 650 | 2 | NIMBUS meteorological satellites[f] (A-4, A-5) |
| Delta | 83 | 1 | Energetic particles satellite (S-3a) |
| Scout | 100 | 1 | Fixed-frequency topside sounder[f] (S-48) |
| | | | Calendar Year 1963 |
| Atlas-Agena B | 1,000 | 1 | Eccentric Orbiting Geophysical Observatory[f] (S-49) |
| Atlas-Agena B | 2,400 | 1 | REBOUND communications satellite (multiple spheres, polar orbit)[f] (A-14) |
| Thor-Agena B | 650 | 2 | NIMBUS meteorological satellites[f] (A-6, A-7) |
| Scout | 100 | 1 | Undefined scientific satellite (International Program Satellite No. 3)[f] (S-53) |
| Scout | 100 | 1 | International satellite No. 2[f] (S-52) |
| Thor-Agena B | 400 | 1 | Orbiting Solar Observatory[f] (S-16b) |
| Atlas-Agena B | 3,300 | 1 | Orbiting Astronomical Observatory[f] (S-18) |

[e] *Vehicle* test and backup launchings, ProjectMercury satellites, and ballistic launchings are omitted from this list. *Spacecraft* test launchings are included. The NASA communications satellite program (here not completely represented) is currently under review with a view toward placing more emphasis on this program.

[f] Proposed flight mission; technical development plan for one or more elements of the over-all vehicle are not yet established.

# C.A.I. LOG

## SECRETARY'S LETTER

**MID-SEASON MEETING**

THE Notice of the Mid-season Meeting was distributed rather later than I should have liked. This was due to a number of hitches, which delayed the final settlement of the programme; getting a programme together in the Christmas season, with its other distractions and dislocated mail services, is not the easiest thing to do. However I think that the result is rather promising. The programme seems to hang together nicely and, without being too narrow, all the sessions have a certain relationship.

I hope that the late distribution of the Notice will not make it difficult for some people to plan to attend. At the first Mid-season Meeting, held in Winnipeg in 1957, 120 registered. In Vancouver in 1958, 145 registered. There was no Mid-season Meeting in 1959 – we held the Special Anniversary Meeting instead – but in Edmonton last year, 161 registered. Let us shoot for at least 180 this time.

**HOLES AND DISMANTLEABILITY**

At the time of writing it is too early to judge the reaction to the introduction of a dismantleable Journal. We shall be interested in comments and suggestions for further improvements to make it more useful.

I particularly hope that our advertisers will be attracted by the idea of catalogue sheets, because this really would serve our readers well. There is another publication which I have bound every year and it always distresses me to throw away some of the advertising; advertisements of the data sheet variety are often well worth keeping for reference and I even started a scrap book at one time, when I was more of a practising engineer than I am now. Had these advertisements been designed for the purpose, things would have been easier and I should probably be collecting them to this day as a matter of habit.

**RAeS LECTURE THEATRE**

We have recently learned a few details of the new Lecture Theatre opened by the Royal Aeronautical Society on the 2nd December. The opening was the culmination of a major project to extend the premises of the RAeS Headquarters in London and I am sure that I speak for all our members in congratulating the Society on this event. The Theatre will seat 310 and is equipped with all the latest facilities for projection, etc.

For a variety of reasons, chiefly geographical, the structure of the RAeS differs significantly from our own. Its Headquarters is the centre of its life as a society, whereas ours is no more than an administrative office; our main activity lies in the Branches and Sections. The Lecture Theatre is therefore a very important asset to the RAeS and the aeronautical world will be the better for it.

**SAE INTERNATIONAL CONGRESS**

I am just back from attending the SAE International Congress and Exposition in Detroit. It was a memorable experience and a great honour to the Institute. Sixteen Canadian and overseas societies were the guests of the SAE – perhaps our most intimate friends were the EIC and RAeS – and the SAE looked after us right nobly. I met ten members of the Institute there, and four or five other Canadians.

The Exposition was largely automotive but there were a few good aeronautical exhibits, including a very effective one by Canadair; it seemed to be attracting a lot of interest. The technical programme ranged over a wide field, aeronautical and otherwise, and included two excellent Canadian papers by Mr. D. B. Rees of the DOT and Mr. J. A. Morley of Canadair.

Several of our Branches already hold joint meetings with their local SAE Sections and I hope that this practice will become more common; for the SAE is interested in all things "self propelled" and certainly theirs is a very practical brand of engineering, which aeronautical people tend to neglect.

# MID-SEASON MEETING

## Marlborough Hotel, Winnipeg

**Monday, 27th February, 1961**

**9.00 a.m.**

**LANDING ENGINEERING**

Chairman
J. W. J. TRURAN
Vice-President, Engineering and Sales
Jarry Hydraulics Ltd.

*The Long and the Short of Runways*
S/L W. M. McLEISH
Senior Aircraft Engineering Officer
RCAF Station Summerside

*Review of the Present and Future Aircraft Brake*
C. R. WEAVER
Manager, Engineering Services Section
B. F. Goodrich Aviation Products

*A Review of Landing Gear on the Caribou Aeroplane*
B. C. ALFORD
Project Engineer
De Havilland Aircraft of Canada Ltd.

**2.00 p.m.**

**RUNWAYS
PREPARED AND OTHERWISE**

Chairman
B. W. TORELL
Supervisor of Engineering
Trans-Canada Air Lines, Winnipeg

*RCAF Snow Removal and Ice Control*
(a) *Introduction*
G/C W. M. DIGGLE
Director of Mobile Support Equipment, RCAF
(b) *The Development of Techniques and Equipment*
F/L J. C. CAIRD
Detachment Commander, Mobile Support Equipment Projects
Central Experimental and Proving Establishment, RCAF

*Operation of Wheel Equipped Fixed Wing Aircraft on Unprepared Land and Snow Surfaces in the Arctic Islands*
W. W. PHIPPS
Vice-President, Bradley Air Services Ltd.

**7.00 p.m.**

**DINNER**

Chairman
DAVID BOYD
President, Canadian Aeronautical Institute

Guest of Honour and Principal Speaker
G. W. G. McCONACHIE
President, Canadian Pacific Air Lines, Ltd.

**Tuesday, 28th February, 1961**

**9.00 a.m.**

**AIR TRAFFIC AND FLIGHT CONTROL**

Chairman
H. D. CAMERON
Executive Assistant to the President
Canadian Pacific Air Lines, Ltd.

*Airspace Management in High Density Areas*
C. F. TIMMERMAN
Director, Air Traffic Requirements, GPL Division
General Precision Inc.

*An Evolutionary Approach to Instrument Flare Out and Landing*
A. J. LJUNGWE
Engineer, Collins Radio Co.

*The Pilot and Air Traffic Control*
R. J. BAKER
Flight Test Engineer-Pilot
Trans-Canada Air Lines

**2.00 p.m.**

**TRAINING BY SIMULATION**

Moderator
W/C P. J. BULA
Directorate of Instruments & Electrical Engineering, RCAF,
in charge of Training Devices Branch

**Panel Discussion**

M. ACKERMAN
Chief Engineer, Simulator Engineering
ACF Industries Inc.

J. W. BELL
Vice-President, Engineering
Canadian Aviation Electronics Ltd.

DR. M. HUMPHRIES
Defence Scientific Service Officer, Human Factors Wing
Defence Research Medical Laboratories

CAPT. G. B. LOTHIAN
Superintendent of Flying
Trans-Canada Air Lines

H. S. RONDEAU
Canadian Representative
Redifon, Canada

## SOME OF THE SPEAKERS

S/L W. M. McLeish

C. R. Weaver

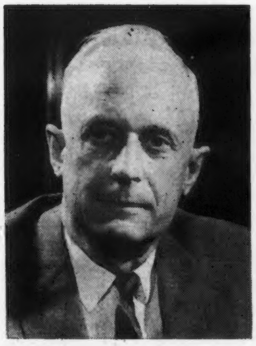
G/C W. M. Diggle

F/L J. C. Caird

W. W. Phipps

C. F. Timmerman

A. J. Ljungwe



R. J. Baker

# MEETINGS

**MID-SEASON MEETING**

The programme of the Mid-season Meeting is set out on the preceding page; notices giving the full programme have been sent to all members of the Institute.

**ABSTRACTS**

The following are abstracts of some of the papers to be presented at the Mid-season Meeting.

*The Long and Short of Runways*

S/L W. M. McLeish–RCAF

The paper deals primarily with the devices which have been evolved in the struggle to improve the effective length of runways to meet the demands of modern aircraft. The correlation of runway lengths, strength criteria, approach and over-run requirements with aircraft wing loading and landing energy is used as a basis for illustrating the achievements and potential of anti-skid wheel brakes, high pressure tires, runway surfaces, runway lighting, tail parachutes, arrester gear, reverse thrust and tail hooks.

Similarly, a discussion of the takeoff problem is made to illustrate the influence of takeoff parameters on runway lengths, and runway and aircraft devices, such as arresting gear, go-no-go takeoff instruments, high lift devices and engine power augmentation.

A brief look is taken at the related factors of approach speeds, sinking speeds, crosswind limitations, turning radii during runway approaches and climb-outs, and, finally, the noise-control influence on takeoff power.

Finally, the future trend of runway development is discussed, and an attempt is made to show that the long runway will always be required for safety purposes even in the coming era of VTOL and STOL aircraft.

*Review of the Present and Future Aircraft Brake*

C. R. Weaver–B. F. Goodrich

The rapid advance of aircraft performance has necessitated an equal improvement in aircraft brakes. A short time ago, the heart of the aircraft brake was organic lining material used with a mild steel or cast iron heat sink in a form of disk or drum. Today, the brake designer has to meet much higher energy capacities and higher torque requirements while being asked to meet very limited weight and envelope specifications.

New metallic brake linings have been developed and used with special alloy steel disks. Today, the lining material joins the disk as a heat absorption member of the brake and both are able to withstand very high temperatures.

Considerable development is being done to improve service life and extend capacities of present brake designs. The liquid-cooled brake system under service test at the present time is an available method for accomplishing this. Other methods will require the use of new materials, such as beryllium, which are currently under development.

*RCAF Snow Removal and Ice Control*

(a) *Introduction*

G/C W. M. Diggle–RCAF

The RCAF shares with the DOT responsibility for runway maintenance including snow removal and ice control on airfields in Canada. This represents a commitment to keep operationally serviceable many millions of square feet of runways, some to meet the next scheduled flight and some to be immediately usable in all weather.

The state of the art on ice and snow dictates the practical approach of trial and error in evolving equipment and techniques. The RCAF cooperates with the US military to test equipment under development and, as a result of test programmes on Canadian equipment, has guided Canadian industry in developing significant improvements.

A short film will be shown, which is used for introductory training of heavy equipment operators and indoctrination of supervisors.

(b) *The Development of Techniques and Equipment*

F/L J. C. Caird–RCAF

When jet-propelled aircraft were first introduced into the RCAF, it became evident that the equipment and operating techniques employed to remove snow and to control ice on RCAF airfields, used by "propeller" aircraft, were outdated and unacceptably slow.

Since then, the RCAF has conducted extensive field tests on various types of equipment, in order to determine the most suitable equipment and operating techniques that should be employed to ensure safe and unrestricted, round-the-clock, all-weather airfield operations.

This paper outlines the tests performed and the up to date equipment and techniques developed for RCAF airfield snow removal and ice control. A film showing the RCAF's latest high speed snow removal concept will also be shown.

*Operation of Wheel Equipped Fixed Wing Aircraft on Unprepared Land and Snow Surfaces in the Arctic Islands*

W. W. Phipps –
Bradley Air Services

Bradley Air Services Ltd. have, over the past four years, pioneered the use of light fixed wing aircraft as an economical means of transport in the Arctic Islands. The company engineered special large, low pressure wheels which permit landings on unprepared land, snow and ice surfaces in a similar manner to a helicopter.

Prior to 1955, geological and other scientific parties used dog teams and boats as a means of transport. With these methods of transport, scientific studies in the Islands progressed at a snail's pace and were confined mostly to coast lines.

Helicopters were not used extensively due to the high cost of operation and limited range. Float equipped aircraft were impractical due to the small amount of ice free water.

During the summer months, Bradley Air Services now operate in the Arctic Islands a fleet of ten Piper Super Cubs equipped with 35 inch diameter wheels and one Beaver equipped with 45 inch diameter wheels.

*Airspace Management in High Density Areas*

C. F. Timmerman – General Precision

Dramatic increases in numbers of landings and takeoffs have posed some critical questions for Air Traffic Control systems. The anticipated growth of aviation will press these services yet harder. Because of this, semiautomatic devices and unique cathode ray tube displays have been designed and are presently undergoing feasibility tests for eventual utilization in the US system.

The semiautomatic devices include a unique tabular display, and the new cathode ray tube displays include the very bright, high resolution television, automatic track-while-scan radar with superimposed numerics and others, all integrated into specially designed consoles, and interconnected with a special air traffic control computer.

*An Evolutionary Approach to Instrument Flare Out and Landing*

A. L. Ljungwe – Collins Radio

Safety of operation, which is largely determined by system accuracy and reliability, is the main consideration in the design of a system, which is able to provide necessary guidance and control for landing aircraft in poor visibility.

It is found that the necessary reliability is higher than that which can now be obtained by available guidance and control equipment. Considerable improvements in system reliability and accuracy can, however, be obtained through redundancy and increased integration of manual and automatic control and monitoring.

An evolutionary program for the attainment of increasingly lower weather minima is outlined in detail.

*The Pilot and Air Traffic Control*

R. J. Baker–TCA

The paper will cover a short résumé of the evolution of air traffic control in Canada, the need for it and its development. An attempt will be made to present the problem particularly from the pilot's viewpoint while airborne, to indicate his requirements as well as those of the ground controller, and the co-ordination between them.

## COMING EVENTS

**CAI**

**27th-28th February, 1961** – *Mid-season Meeting,* WINNIPEG, MAN.

**BRANCHES**

**Tour Speakers**

*Advanced Systems Planning Looks at VTOL in Peace and War,* W. S. GEDDES.

**20th March** – Vancouver
**21st March** – Edmonton
**22nd March** – Calgary
**23rd March** – Winnipeg

*A Review of Technical Requirements for the Operation of Aircraft at Sea,* CDR J. F. FRANK.

**15th March** – Ottawa
**22nd March** – Montreal
**23rd March** – Quebec

*Solutions to Aircraft Store Separation Problems,* T. B. FESSENDEN.

**19th April** – Halifax-Dartmouth
**20th April** – Quebec

**Quebec**

**21st February** – *Some Thoughts on the Corrosion of Non-Ferrous Metals,* T. HOWARD ROGERS, OFFICER IN CHARGE, NRE DOCKYARD LARORATORY, DRB.

**Vancouver**

**22nd April** – CANYON GARDENS, *Annual General Meeting and Dance.*

***Note***

The Editor would welcome details of forthcoming meetings of other societies which would be of interest to members of the Institute.

# BRANCHES

**Quebec**

Reported by F. Jackson

*November Meeting*

The November meeting of the Quebec Branch was held at Carling Breweries Ltd. at 8.30 pm on the 30th November. Approximately 20 members and guests attended.

The Branch Chairman, Dr. H. M. McMahon, welcomed the Secretary of the Institute, Mr. H. C. Luttman, who gave a brief account of the current CAI situation.

The scheduled speaker was unable to be present and instead a talk was given by Mr. L. A. Dickinson, Head of the Rocket Engine Development Section at CARDE. Mr. Dickinson outlined some of the problems associated with the combustion of solid propellants, with particular emphasis on the phenomena of erosive burning. The CARDE-developed technique of determining burning rates by the use of accurately located probes embedded in a propellant was described. Some of the interesting results obtained from firings of engines 8 inches in diameter and 80 inches long were presented.

The Quebec Branch is indebted to Mr. Dickinson both for acting as replacement speaker at very short notice and for his clear and stimulating presentation. He must have been gratified by the spirited discussion which followed the talk, not all of which was due to the locale.

As a result of this meeting, the Quebec Branch feels that the presentation of a technical talk, involving current unsolved research problems, can be quite successful and useful if presented in a lucid manner, with sufficient time for discussion.

The speaker was thanked by Dr. McMahon, who also expressed the appreciation of the Branch to Carling Breweries Ltd. for the "refreshments".

**Montreal**

Reported by W/C H. J. M. Londeau

*November Meeting*

The Montreal Branch held a dinner meeting on Tuesday, 15th November, at the Airlines Cafeteria, ICAO Building, at which 46 members attended dinner and 96 members heard the talk by Mr. A. A. Lombard.

The Chairman, Mr. D. R. Taylor, introduced the Head Table at dinner; W/C H. J. M. Londeau, Mr. J. T. Dyment, Mr. A. A. Lombard, Mr. D. R. Taylor and Mr. E. H. Higgins.

Subsequent to dinner, the Chairman reminded members of the need for their whole-hearted support in the Branches' drive for new CAI members. He advised the meeting of the Branch Executive's activities to increase Sustaining Membership and asked members to advise Mr. C. M. Newhall of any potential members.

The Chairman asked Mr. Higgins to introduce Mr. A. A. Lombard. Mr. Higgins briefly outlined Mr. Lombard's career from 1940, when he was engaged in jet engine design at the Rover Company in the UK. In April, 1943, Mr. Lombard became Chief Designer of Rolls-Royce Northern Factories, and subsequently Chief Designer of Rolls-Royce Aero Division in 1952. In December, 1954, he was appointed Chief Engineer, Rolls-Royce Aero Division and since July 1958, Mr. Lombard has been a Director of Rolls-Royce and Director of Engineering, Aero Division.

Mr. Lombard gave a stimulating address, supported with coloured slides, on "Current Developments in By-Pass Jet Engines". He briefly compared the fan and by-pass engines before discussing detail characteristics and development problems of Rolls-Royce engines.

The speaker outlined development problems which arose during operation of Rolls-Royce engines. Only by overcoming these difficulties can reasonable overhaul life be achieved. For example, the Dart started out at a 1000 hours and has progressively increased to 3300 hours. The commercial Avon has reached 2300 hours and the Conway, which started at 1000 hours, is now at 1200 hours. Premature removals with the Conway have been 0.426 per 1000 hours giving an average life of 940 hours. A controlling factor of overhaul life, of course, is the turbine entry temperature – 1335°K for TET is quite a high value and necessitates either air-cooled blades or development of better high temperature steels.

Rolls-Royce engines have acquired more than 250,000 hours with air-cooled blades during the past 10 years, and have had engines with such turbine blades in airline operations for 3 years. Mr. Lombard discussed the design advantages of air cooled blades, and considerable discussion ensued on this subject during the question period.

The speaker showed slides to illustrate the design history of pressure ratio with time (a linear relationship) and stressed the need for high pressure ratio engines with high subsonic transport aircraft, to obtain optimum specific fuel consumption. For example, the RB-141 has a PR of 16.8 and the Co-12 a PR of 14.8.

The controversy of aluminum/titanium/steel blades for compressors was presented in some detail by Mr. Lombard, and he showed the effect of damage on fatigue strength under normal impact conditions. The notch sensitivity of these materials is an important consideration in compressor design. Other topics discussed were rotor axial clearance, thermal shock (Nimonic 105) and cyclic testing.

A lively discussion followed for half an hour, after which Mr. Dyment thanked the speaker for a most entertaining talk and highlighted several areas which were of interest to TCA.

**Vancouver**

Reported by M. G. Brechin

*December Meeting*

The December meeting was held on December 14th, 1960, at the RCAF Officers' Mess, Sea Island. As is the custom with the Vancouver Branch this was "Ladies' Night" with some 20 of the "better-half" in attendance along with members and other guests.

After a short business session conducted by the Chairman, Mr. F. L. Hartley, the guest speaker was introduced.

The speaker, the Hon. P. A. Gaglardi, Minister of Highways for the Province of British Columbia and Minister of the Calvary Temple in Kamloops, but better known to the residents of the West Coast Province as "flying Phil" for his escapades on his own highways, selected as his subject "The Future of Aviation in British Columbia". A more descriptive title would have been "Speed and Time". An enthusiastic and interested follower of aviation, world traveller and youth worker, the Hon. P. A. Gaglardi uses air travel considerably.

Whilst the speaker touched briefly on the subject of his address, he spoke

of progress, time and speed, especially where the challenging business of aviation was concerned. Progress, something we look forward to in this day and age, has in a few short years seen the transformation from piston powered aircraft to jet propelled aircraft. People are not satisfied with not wanting to go in a hurry, and time is thus speeding us to our inevitable goal. Time is also our enemy especially to the ladies who would like to remain twenty-nine. However, by using speed we are losing time which in turn creates age.

The advent of "Hovercraft" travelling 5 ft to 10 ft over the sea carrying hundreds of passengers at speeds up to 100 mph was foreseen by the speaker to replace the present ferries between the mainland and Vancouver Island.

The most assured method of travel in the future will be by the aeroplane. The crudest, the motor car. The not too distant future will see travel from Vancouver to London, England, in a matter of a few hours, shorter than the automobile trip from downtown Vancouver to the airport.

The dynamic speaker, an ordained minister of his own church, paralleled much of his speech with biblical and biological examples of the present day inventions. He emphasized "there is nothing new under the sun". We are only rediscovering counterparts of what God has had for years. For example, the squid was the first to have the principles of jet propulsion.

50% to 70% of the development of British Columbia is due to the aeroplane. Future development of the Province should see this figure rise to at least 75%. It is conceivable that there will no longer be a need for a minister of highways, but a minister of airways.

In closing, the speaker suggested that in fifteen to twenty years personal aircraft will be commonplace, especially the VTOL types which even grandma may control. However, no matter where one flies the greatest place to fly is Heaven.

After a short but lively question period, the speaker was thanked by Mr. R. J. Burden.

**Halifax-Dartmouth**

Reported by F. T. Dryden

*December Meeting*

The regular meeting of the Branch was held in the cinema of the Chief Petty Officers' Mess, HMCS Shearwater, on Wednesday, the 15th December. 22 members and guests were present. The Branch Chairman, LCDR G. M. Cummings, presided.

The Chairman expressed his thanks, on behalf of the Branch, to the CPO's Mess for providing the use of the cinema as a meeting place.

It was a blow to the members present to learn that the Chairman had been appointed to HMCS Crescent, and that his Branch activities will be curtailed in the New Year.

The Branch as a whole wishes LCDR Cummings every success in his new appointment.

Prof. O. Cochkanoff, the Vice-Chairman, will be carrying the load during the Chairman's absence.

Mr. T. H. Rogers, the speaker for the evening, was then introduced by the Chairman.

Mr. Rogers stated that his topic was "Corrosion" and he showed a three reel film entitled "Corrosion in Action". Mr. Rogers further supplemented the film with many technical gems from his vast experience, and covered the subject from both a practical and theoretical standpoint. In conclusion, the speaker stated that corrosion presents a great economic loss to industry and that the Royal Navy had calculated its loss annually to be approximately £10,000,000.

A very interesting question period ensued.

The guest speaker was thanked by Mr. W. G. Stewart.

**Toronto**

*December Meeting*

Reported by K. A. Kinsman

The December meeting was held at The De Havilland Aircraft's cafeteria on Tuesday, the 13th December at 8.15 pm. Mr. C. H. Bottoms, Chairman of the Toronto Branch, opened the meeting and welcomed 35 members and 15 guests to hear Mr. D. J. Underwood and Mr. A. H. Green, from Computing Devices of Canada Ltd., talk on the Decca Navigation System. Mr. Bottoms reminded everyone about the next meeting on the "Jet Flap" to be held on Thursday, the 5th January, 1961, at the UTIA and the dire need to encourage new membership in the CAI.

Mr. W. T. Heaslip, Assistant Chief Designer of De Havilland and Vice-Chairman of the Toronto Branch, was called on to introduce the two speakers. Mr. D. J. Underwood has been with the Air Section of CDC for 3½ years with many previous years' experience as a pilot with BEA. Mr. A. H. Green has many years' experience with the Systems and Surveys Division of CDC.

Mr. Underwood began with a short explanation of the navigation systems used by the British and the USA (British – Decca; USA – VOR and DME) and of the international controversy which exists over the two systems. VOR stands for VHF omnirange, which presents to the pilot a bearing to or away from a VOR ground station. DME is distant measuring equipment, which when used with VOR will give the range in nautical miles to a VOR station.

A coloured film followed illustrating a Decca navigator on board a Viscount and how it presents a pictorial presentation of aircraft position to the pilot.

Mr. Green followed with a short history of the Decca system. The original concept of Decca began just before the last war. A Mr. Brian showed a prototype to the US authorities, who said they saw no future for it. The British, however, were very interested and used it on D Day to lead invasion forces into France.

Post-war gave some financial problems but it soon proved successful and now there are many commercial Decca chains in existence. Canada has four chains with three operational at present.

Decca is a short range, low frequency (70-130 kc) system which works on phase comparison between a master and three slave transmitting stations. This interaction defines hyperbolae which are called Decca lanes. Accuracies of 150 ft can be obtained over a wide area, making this one of the most accurate systems available.

Accuracy depends on two things; range and pattern stability. Mr. Green proceeded to use the blackboard to illustrate these functions along with the standard lane deviation. It was interesting to note that pattern stability depended on equipment condition and terrain conditions over which the waves must pass. Sea water is very stable and is used as a basis for all computations.

Decca has developed a flight log for pictorial presentation to the pilot. It uses a roller map with a transverse pen, which move at right angles to one another. Mr. Underwood brought along samples of a flight log and other cockpit presentation instruments.

A long range system of Decca is called Dectra. Dectra is used in Newfoundland for North Atlantic traffic and signals from this station have been picked up in Alaska.

A new British system called DIAN (Decca Integrated Airborne Navigation) feeds information from Decca, Dectra and Doppler into the flight log.

A second film was shown illustrating how Decca was used by the Department of Mines in a geological survey of the Canadian Arctic.

A question period followed where further explanation was given on lane identification and system operation.

Mr. D. J. Dalzell, Sales and Service Manager of CARL, thanked the two speakers for their informative talk.

Mr. Bottoms adjourned the meeting at 10.15 pm.

*January Meeting*

Reported by C. F. de Jersey

The January Meeting of the Toronto Branch was held at the University of Toronto, Institute of Aerophysics, by the kind permission of Dr. G. N. Patterson, Head of the Institute, whose good offices had sponsored the speaker, Dr. D. A. Spence of the Royal Aircraft Establishment.

Dr. Patterson opened the meeting by welcoming the "standing room only" audience of 126 members and guests, and having outlined the programme for the evening, asked Dr. G. K. Korbacher of the Institute to introduce the speaker.

During his introductory remarks, Dr. Korbacher mentioned that some two hundred papers had been published on the speaker's subject, pointing out the fact that the last decade had involved considerable investigation in the USA, France and the UK upon the various facets of jet flap applications for aircraft.

Dr. Spence is at present on sabbatical leave from the RAE, and has spent the 1959-60 university semester at Cornell and from there proceeded to the California Institute of Technology in the role of visiting professor.

Dr. Korbacher reminded the audience that Dr. Spence had obtained his PhD in 1952 with a thesis entitled "Turbulent Boundary Layers", and in consideration of this and the work he has accomplished during the subsequent years, he felt we were singularly honoured by having Dr. Spence with us to present his paper "Aerodynamics of Jet Flaps".

The speaker laid the foundation of his talk by describing the work done in the past particularly by Schubauer, Hagedorm and Ruden, Davidson and Stratford, and mentioned in passing an amusing point, that the immense importance of their thinking in the last decade had required the highest security classifications being placed on the investigations. However Dr. Spence pointed out that most modern thought stemmed from the thesis prepared 30 years ago by Schubauer, which is of course readily available to any interested party!

**The Ottawa Branch Executive Committee (l to r) Lt J. M. Vivian, Mr. G. D. Watson, G/C E. P. Bridgland and Mr. J. R. Stallabrass**

The advent of the jet turbine has given us the opportunity of integrating both lift and thrust, utilizing the same power origin, and this, together with the demand for increasingly effective lift and control augmentation systems, has brought about a tremendous revival of thinking about jet flaps in general.

Dr. Spence highlighted his most interesting paper by a number of comprehensive slides covering his detailed investigations with both the jet blown flap and jet curtain blown from the rear of the airfoil chord.

In describing his own contribution to the subject, Dr. Spence showed the development of linearized equations for a simplified model in inviscid flow, and gave a comparative physical interpretation of the resulting integral equation. He suggested some probable effects of viscosity on the simplified solution, explaining its relationship to experimental results.

This was followed by a description of some subsequent work on unsteady flow, which gave some insight into the behaviour of jet flaps in gusts and manoeuvres.

It would be impossible to reproduce the blackboards of formulae and the involved curves from Dr. Spence's slides here, but suffice it to say that the speaker was held by the audience for a full two hours before Dr. Patterson took compassion on him, and asked Mr. J. P. Uffen, Chief Aerodynamist of De Havilland Aircraft, to propose a vote of thanks both on behalf of the CAI and the Institute of Aerophysics.

**Ottawa**

Reported by Lt J. M. Vivian

*December Meeting*

The monthly meeting of the Branch was held on Thursday, the 8th December, in the Science Auditorium of the University of Ottawa. There was a very light turn out with only 23 members and guests attending. This may have been a result of local conditions as it was a dry, cold evening. The "dry" in this case applies only to weather and bar facilities and not to the lecture. Those less hardy souls who were not prepared to brave the elements missed a well prepared and delivered talk. It is hoped that a better turn out may be expected at future meetings.

Mr. G. D. Watson, Chairman of the Branch, opened the meeting and introduced the speaker, Dr. J. J. Green, Chief Superintendent of the Canadian Research and Development Establishment. Dr. Green has had a long association with aeronautics in Canada. A graduate of London University he was the Head of the Aerodynamics Section of the National Research Council from 1930 to 1943. Following a tour with the RCAF, he was the Chief Research Aeronautics Engineer on the Air Transport Board from 1945 to 1949, and has since been with the Defence Research Board in various positions including that of Defence Research Member in Wash-

ington. He has been in his present position since September, 1959.

The subject of Dr. Green's lecture was a review of papers presented at the Second International Congress of the Aeronautical Sciences, which was held in Zurich in September. Dr. Green began his talk by brandishing a manuscript of his lecture, of very impressive dimensions, with the threat that it would take at least four hours to present its contents. The threat did not materialize however, as he restricted his coverage to a résumé of selected papers which he felt would be of the most interest to the members present. Those subjects covered included three papers on Aerodynamics, three papers on Structures, a paper on Airline Economics and a paper on Discoveries from Satellite Orbits. It is understood that it is intended to include in a DRB publication a full report by Dr. Green on all of the papers presented at Zurich.

The speaker was thanked by Mr. J. L. Orr, who expressed the pleasure of the Branch in welcoming back one of its founder members.

*January Meeting*

The January Branch meeting was held on Wednesday, the 11th January at the University of Ottawa. A total of 34 members and guests attended.

The meeting was opened by Mr. G. D. Watson, Chairman of the Branch. G/C E. P. Bridgland was called upon to introduce the speaker, Mr. H. T. Stevinson of the National Aeronautical Establishment, Flight Research Division.

The subject of Mr. Stevinson's lecture was "The Design and Development of a Crash Position Indicator". The need for such an indicator was aptly illustrated by a series of aerial photographs of crash scenes in which the wreckage was almost indiscernible. A visual search must subsequently be carried out at ranges not exceeding ⅓ mile. A crash position indicator with a range of only 10 miles would therefore increase the search path width thirty times over that of a visual search path. Mr. Stevinson stated that, although there has been an improvement of safety in air travel of 50 to 1 since 1928, 70% of the aircraft that do crash today are destroyed on impact. It is therefore also essential that position indicator equipment be fully automatic.

Experiments with crash indicating devices began as early as 1931. Following the war, the National Research Council carried out tests on a self righting, cylindrical shaped indicator which was lowered by parachute. Experiments indicated that the design was impractical, and in 1955 the study of a more suitable deceleration vehicle, the tumbling aerofoil, began. This device proved to be most satisfactory. Of light plastic foam construction, the kenetic energy of the unit is rapidly dissipated through its rotational motion through the air. The landing speed of 30 to 40 mph is adequate for any terrain, as the energy absorbed through crashing the foam will protect the sealed transmitting unit up to a loading of 200g. The high frequency transmitter has a range of 30 miles under ideal conditions and 10 miles under the most adverse conditions, i.e. surrounded by high hills. When installed on the aircraft the batteries in the unit are provided with a trickle charge from the aircraft power supply. The batteries have sufficient power to operate the transmitter for a period of 5 days.

The indicator is released from the aircraft by mechanical means. A tensioned wire extends from the release mechanism on the aft surface of the fuselage to a crash sensing probe on the under surface of the nose. If the probe is crushed or structural damage to the fuselage occurs, the tension is released from the wire and the indicator is jettisoned.

Films of various tests and experiments conducted on the indicator were shown. These included launches into a vertical shale bank from a rocket sled travelling at 230 mph, drops from an aircraft in flight, tests with the unit immersed in snow, tests at sea etc. The acid test however occurred when an indicator was installed on a light aircraft which later crashed in the arctic. The unit released on impact and functioned perfectly for its designed life of five days.

It is estimated that the cost of the installation of the release mechanism and indicator will be between $700 to $1000. In view of the millions of dollars expended yearly on search and rescue operations this price was not considered prohibitive.

The speaker was thanked by Mr. A. N. le Cheminant. He expressed his disappointment that the NRC development has not, as yet, been more widely accepted by the aviation industry, and the hope that the requirement for installations of crash position indicators will become more generally recognized.

## ANNUAL GENERAL MEETING

### TORONTO

### 25th and 26th May, 1961

# MEMBERS

## NEWS

**Dr. E. R. Sharp, F.C.A.I.,** has recently announced his retirement as Director of NASA's Lewis Research Center.

**H. K. Malinowski, A.F.C.A.I.,** has relinquished his position as Senior Systems Engineer at Avro Aircraft Ltd. to take a similar position with The De Havilland Aircraft of Canada Ltd.

**R. Smallman-Tew, A.F.C.A.I.,** formerly Chief Metallurgist at Avro Aircraft Ltd., has taken a position in the Structures Dept. at the National Aeronautical Establishment in Ottawa.

**G. Haigh, M.C.A.I.,** has been transferred by Trans-Canada Air Lines from Winnipeg to their Montreal base.

**F/O A. J. Robinson, M.C.A.I.,** formerly Detachment Commander, 1002 TSD, Northwest Industries Ltd., Edmonton, has moved to Montreal to take up the position of Senior Quality Control Review Engineer at Canadian Pratt & Whitney Aircraft Ltd.

**H. I. Daffin, Technical Member,** has been appointed Rolls-Royce Representative at San Francisco International Airport.

## DEATH

It is with deep regret that we record the death on the 28th January of **W/C H. Pearce, A.F.C.A.I.**

## OBITUARIES

### The Right Honourable C. D. Howe

The death of the Right Honourable C. D. Howe has ended a life full of service to Canada. Mr. Howe was a man of great abilities, and his contributions as a leader of business, a politician, and a great administrator have been set out in the many eulogies that followed his passing. In this Journal, it does not seem necessary to repeat these but rather to discuss Mr. Howe's contribution to the profession of engineering, his work with the air industry and his personal qualities.

After receiving his degree from MIT, Mr. Howe was first a teacher of engineering, and later in his own firm recognized throughout the world as a designer and builder of the first rank. His professional success was perhaps due in a small way to his early work in teaching, for he often said that the best way to learn a subject properly was to have to teach it. Despite his pre-eminent position in the profession, it is paradoxical that Mr. Howe's greatest contribution to engineering came as a result of his great abilities as an organizer and administrator, for his masterful handling of some of the largest undertakings in Canada showed clearly the value in many other fields of an engineering background.

Mr. Howe's work with the air industry was most important. He created and took a great interest in Trans-Canada Air Lines, now one of the great airlines of the world. The wartime growth of aircraft manufacturing, its post war re-alignment and its build up during the Korean war all occurred under his direction and leadership. His interest in aviation can be seen by his acceptance of an Honourary Fellowship in the CAI, his stature in the rest of the aviation world evidenced by his receipt of the Guggenheim Medal in 1954. The citation on that occasion reads as follows:

> "Clarence Decatur Howe – Engineer and Statesman, Minister of Trade and Commerce, and Minister of Defence Production, for initiating and organizing commercial air routes and service, promoting aeronautical research, development and production of aircraft and engines, and advancing the art of aeronautics."

Any man who achieves great things is a centre of attention. Mr. Howe was no exception, and the glare of the limelight which surrounded him obscured his real nature. He was a man of the finest character, one who supported his subordinates to the full and took the responsibility for their errors. While he was firm and resourceful, and not given to hesitation in the face of difficult decisions, he was by no means arbitrary. To have worked with him and to have known him, was a great privilege.

Mr. Howe and his family have suffered a great loss, and all the air industry will want to extend the most sincere condolences to them.

T. E. Stephenson

### W/C H. Pearce

The National Coordinating Council for the Golden Anniversary of Flight in Canada was a body set up in September 1957 to coordinate the anniversary celebrations of its member organizations, which included the RCAF, the AITA, the CAI and nine others. In April 1958 W/C Harold Pearce, who had just retired from the RCAF, was appointed "Coordinator", or permanent manager, of this body and occupied an office in CAI Headquarters. It was in this capacity that I got to know him very well during the next twelve months.

Others must speak of his thirty years of distinguished service with the RCAF, of his war service, which was devoted almost exclusively to the development of photo reconnaissance, and of his eminence in the field of aerial survey and photogrammetry. I know only that somewhere in the Canadian North there is a lake named after him and that for the Special Golden Anniversary issue of the Canadian Aeronautical Journal he contributed an authoritative paper entitled "Canada and the Airborne Camera". But I can speak of the last three years of his life, when he derived such intense enjoyment from applying his broad experience of Canadian aviation to the celebration of its Golden Anniversary and looked forward to spending a few years in England "visiting cathedrals and doing a spot of painting".

He was a gifted artist in water colours and his interest in the history of aviation resulted in some excellent sketches of historic aircraft. I believe that he did a series for the National War Museum. When Dr. A. E. Russell delivered the W. Rupert Turnbull Lecture before the Institute, he presented us with a propeller designed by Dr. Turnbull during the first World War; moreover his lecture contained some photographs of the Sage aircraft for which this propeller was intended. From these photographs Hal produced a painting, which he presented to the Institute and which now hangs in my office below the propeller.

Hal Pearce was an ideal Coordinator. He was tremendously interested in the Golden Anniversary and he had plenty of ideas. He "knew everybody" and soon became a close personal

friend of all the representatives of the member organizations of the National Coordinating Council. I am sure that they will all agree with me when I say that it was a delight to work with him; and since we were in adjoining offices I worked more closely with him than any of the others. Nothing was ever too much trouble; he was full of fun; and all the CAI staff loved him.

After the work of the Council was completed, he joined the Standard Motor Company (Canada) Ltd. in Toronto – he had always been an enthusiastic admirer of their products –but he became seriously ill last summer. He seemed to recover and went to England for convalescence and, as he told me when he visited this Headquarters in August, to "visit cathedrals and do a spot of painting". Tragically he collapsed on arrival in England and he died on the 28th January.

The CAI still has his painting and there is still a Lake Pearce in the Canadian North. But many of us have lost a great friend.

H. C. LUTTMAN

**ADMISSIONS**

At a meeting of the Admissions Committee, held on the 2nd January, 1961, the following were admitted to the grades shown.

***Associate Fellow***

**G. I. Robinson,** Chief Test Engineer, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.: *1805 Blvd. du Lac, St. Eustache-sur-le-Lac.*

***Member***

**S/L G. A. Heck, RCAF,** RCAF/AFHQ, Operational Requirements, Ottawa, Ont.: *207 Maclaren St., Apt. 202, Ottawa, Ont.*

**F/L A. H. Hoogen, RCAF,** CEPE Detachment, RCAF, Plant 2, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.

**M. Lajeunesse,** Service Engineer, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.: *8323 Foucher St., Montreal, P.Q.*

**Lt J. L. Langlois, RCN,** Air Electrical Officer, HMCS Shearwater, N.S.: *Box 146 Shearwater, N.S.*

**G. F. McConachie,** Foreman, Instrument Section, Canadian Pacific Air Lines (Repairs) Ltd., Calgary, Alta.

**Lt A. M. Percy, RCN,** Engineering Control Officer, Air Maintenance Centre, RCN Air Station, Shearwater, N.S.: *16 Penhorn Drive, Westphal, Dartmouth, N.S.*

**L. P. Rowley,** Senior Engineer, Dynamic & Systems Test Section, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.: *178 Braebrook Ave., Pointe Claire, P.Q.*

**G. B. Weld,** Assistant Professor, Nova Scotia Technical College, Halifax, N.S.

***Technical Member***

**D. M. Alexander,** Imperoyal Post Office, Halifax County, N.S.

**F/O E. Carter-Edwards, RCAF,** Station Construction Engineering Officer, RCAF Station Sea Island, B.C.: *667 Heakes St., Richmond, B.C.*

**P. B. Eckland,** Instrumentation Engineer, Computing Devices of Canada Ltd., P.O. Box 508, Ottawa, Ont.: *66 Cherbourg No., Ste. Foy, P.Q.*

**Dr. L. Elias,** High Speed Aerodynamics Lab., National Research Council, Ottawa, Ont.

**Prof. M. Gauthier,** Mechanical Engineering Dept., Ecole Polytechnique, 2500 Guyard Ave., Montreal, P.Q.

**G. W. Haight,** Room 302, Bldg 4, 70 Lyon St., Ottawa 4, Ont.

**Lt R. G. F. Jekyll, RCN,** Wardroom, RCN Air Station, Shearwater, N.S.

**J. S. Kuchta,** Combustion Engineer, Canadian Pratt & Whitney Aircraft Co. Ltd., P.O. Box 10, Longueuil, Montreal, P.Q.: *6350 - 11th Ave., Rosemont, Montreal 36, P.Q.*

**D. M. Martin,** Product Applications Engineer, Lear, Inc., 110 Ionia N.W., Grande Rapids, Mich.: *907 Beechwood N.E., Grand Rapids 5, Mich.*

**F/O P. S. Perry, RCAF,** RCAF Station Sea Island, B.C.

**I. R. Pilkington,** RCN Air Station Shearwater: *376 Robie St., Halifax, N.S.*

**J. C. Pluchinsky,** Analytical Engineer, Canadian Pratt & Whitney Aircraft Co. Ltd., P.O. Box 10, Longueuil, Montreal 23, P.O.: *5101 Rosemount Blvd., Montreal, P.Q.*

**CPO V. R. Vanderwater, RCN,** HMCS Shearwater, N.S.

**W. S. Weston,** Air Engineer, Ilford & Rivington Airways, Winnipeg, Man.: *414 Moorgate & Ness, St. James, Man.*

**F/L R. A. White, RCAF,** RCAF/CEPE Test Pilot, Northwest Industries Ltd., Municipal Airport, Edmonton, Alta.

***Student***

**T. F. Bagg,** Loyola College: *1040 Manning Ave., Verdun, P.Q.*

**F. W. Bosanac,** University of Toronto: *4 Poplar St., Schumacher, Ont.*

**F. Cicci,** University of Toronto: *381 Hillmount Ave., Toronto 19, Ont.*

**C. E. Dumas,** Ecole Polytechnique: *21 Gouin Blvd. W., Montreal, P.Q.*

**B. W. Gowans,** University of Toronto: *17 Boswell Ave., Toronto 5, Ont.*

**R. L. Hebert,** Loyola College: *450 Gratton, St. Laurent, P.Q.*

**P. C. Hughes,** University of Toronto: *80 Don Valley Dr., Toronto 6, Ont.*

**F/C C. Johnston,** 5818, 3 Squadron, Royal Military College, Kingston, Ont.

**J. J. Kramar,** University of Toronto: *109 Garnet St., St. Catharines, Ont.*

**C. K. C. Kwok,** McGill University: *212 Milton St., Apt. 2, Montreal, P.Q.*

**Miss C. Malouin,** Ecole Polytechnique: *8600 St. Urbain St., Montreal, P.Q.*

**P. Oelmann,** McGill University: *130 Lewis Ave., Westmount, Montreal 6, P.Q.*

**F/C P. R. H. Sanderson,** 5837, 3 Squadron, Stone Frigate, Royal Military College, Kingston, Ont.

**P. Savage,** Ecole Polytechnique: *4739 Adam St., Montreal 4, P.Q.*

**F/C T. A. Spruston,** 2 Squadron, Royal Military College, Kingston, Ont.

**P. R. Stephens,** University of Toronto: *37 Bristol Ave., Toronto 4, Ont.*

**K. K. Tam,** University of Toronto: *205 South House, 1 Devonshire Place, Toronto 5, Ont.*

**E. M. Traczyk,** McGill University: *4680 Pie IX Blvd., Apt. 2, Montreal, P.Q.*

**Y. Trepanier,** Ecole Polytechnique: *335 - 41st Ave., Lachine 32, P.Q.*

**C. Tupinier,** Ecole Polytechnique, Lac Guindon, Cte. Terrebonne, P.Q.

**F/O A. M. Valenti,** Hypersonics Group, Mechanical Engineering, McGill University, Montreal, P.Q.

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***Associate***

**K. Gibbens,** Aviation Editor, The Telegram, Bay Street, Toronto 1, Ont.

* * *

At a meeting of the Admissions Committee, held on the 11th January, 1961, the following were admitted to the grades shown.

***Associate Fellow***

**T. D. Earl,** Chief Aerodynamicist, Avro Aircraft Ltd., Box 4004, Terminal A, Toronto, Ont.

*Member*

**F/L A. Bowman, RCAF,** CEPE Detachment, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.: *266 St. Laurent St., Rosemere, P.Q.*

**D. Brown,** Assistant Research Officer, National Research Council, Ottawa, Ont.: *23 Kelvin Crescent, Box 116, R.R. No. 3, Ottawa, Ont.*

**LCDR G. G. Croswell, RCN,** Officer-in-charge Technical Services, Aircraft Maintenance Centre, HMCS Shearwater, N.S.: *24 Joffre St., Dartmouth, N.S.*

**M. Dimentberg,** Civil Aviation Branch, Dept. of Transport, 6th Floor, Main Post Office Building, Winnipeg 1, Man.

**J. W. L. Fox,** Group Leader, The De Havilland Aircraft of Canada Ltd., Downsview, Ont.: *45 John Street, King City, Ont.*

**F. S. Hiley,** Trans-Canada Air Lines, Engineering Dept., Winnipeg Airport, Winnipeg, Man.

*Technical Member*

**S. F. Bell,** Dept. of Defence Production, 70 Lyon St., Ottawa, Ont.: *Apt. 3, 1893 Carling Ave., Ottawa, Ont.*

**J. E. Benson,** Bristol Aero-Industries Ltd., Vancouver Airport, B.C.: *736 McMath Road, Richmond, B.C.*

**D. E. Butcher,** Draftsman, Rolls-Royce of Canada Ltd., Box 1400, St. Laurent, Montreal, P.Q.: *2287 Old Orchard Ave., Apt. 12, Montreal, P.Q.*

**T. M. Cox,** Weight and Balance Technical Engineering Dept., Fairey Aviation of Canada Ltd., Box 69, Dartmouth, N.S.: *3 Crichton Park Road, Dartmouth, N.S.*

*Junior Member*

**A. L. Berg,** Draftsman, Pacific Western Airlines, Edmonton, Alta.: *11020 - 115th St., Edmonton, Alta.*

**L. J. Collett,** Lucas-Rotax Ltd., Vancouver Airport, B.C.: *857 - 27th Ave. E., Vancouver 10, B.C.*

*Student*

**H. D. L. Gordon,** University of Toronto: *c/o Col. H. D. L. Gordon, 14 Beaumont Rd., Toronto, Ont.*

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*Associate*

**LCDR H. J. Bird, RCN,** Naval Plans Staff, NDHQ: 27 *Entrance Ave., Lynwood Village, Bells Corners, Ont.*

**J. A. Caine,** Salesman, James B. Carter Ltd., P.O. Box 962, Winnipeg, Man.

At a meeting of the Admissions Committee, held on the 18th January, 1961, the following were admitted to the grades shown.

*Associate Fellow*

**W/C W. R. Cole** (on transfer from Member)

**J. G. Theilmann,** Helicopter Division, Spartan Air Services Ltd., Ottawa, Ont.: *Box 58, R.R. No. 5, Ottawa, Ont.*

**R. F. Wilkinson,** Deputy Chief Superintendent, Defence Research Board, CARDE, P.O. Box 1427, Quebec, P.Q.: *2825 rue Montarville, Ste. Foy, Quebec 10, P.Q.*

*Member*

**M. G. Brechin** (on transfer from Associate)

**W. J. Clarke** (on transfer from Technical Member)

**B. R. Dudley** (on transfer from Technical Member)

**S. N. Laing,** Technical Development Engineer, Solex Ltd., 223-231 Marylebone Road, London N.W.1, England: *11 Greenford Ave., Southall, Middx., England.*

**Dr. I. G. Liu,** Aerophysics Wing, CARDE, P.O. Box 1427, Quebec, P.Q.

**LCDR B. W. Mead, RCN,** Commanding Officer, Experimental Squadron 10, Shearwater, N.S.: *10 Dustan St., Dartmouth, N.S.*

*Technical Member*

**R. R. Clifford** (on transfer from Junior Member)

**W. H. Davison** (on transfer from Junior Member)

**F/O J. Y. V. P. De La Durantaye** (on transfer from Student)

**F/O L. A. Harvey** (on transfer from Junior Member)

**C. V. Healey** (on transfer from Student)

**P. H. Hinton** (on transfer from Student)

**F/L T. L. Hogg, RCAF,** Aircraft Repair Officer, RCAF Station Lancaster Park, Alta.: *13011 - 93rd Street, Edmonton, Alta.*

**O. Hunt,** Engineer, Canadian Aviation Electronics Ltd., Box 2030, St. Laurent, Montreal 9, P.Q.: *Box 1127, RCAF Station Cold Lake, Alta.*

**J. H. S. Lee** (on transfer from Student)

**F/L E. J. Lister, RCAF,** CEPE, Canadair Ltd., P.O. Box 6087, Montreal, P.Q.: *564 - 68th Ave., L'Abord a Plouffe, P.Q.*

**L. E. Macartney,** Mechanical Engineering Division, National Research Council, Ottawa, Ont.

**P. G. MacKay** (on transfer from Junior Member)

**F/O D. R. McIntosh, RCAF,** Aircraft Engineering Officer, RCAF Station Sea Island, B.C.: *1155 W. 70th Ave., Vancouver 14, B.C.*

**N. G. Moir,** Lead Hand, Neptune Engine Repairs, Fairey Aviation Co. Ltd., P.O. Box 69, Dartmouth, N.S.: *42 Russell St., Dartmouth, N.S.*

**A. F. Mosher,** Sales Engineer, Philip French Sales Ltd., 8425 Mountain Sights Ave., Montreal 16, P.Q.: *57 Dromore Crescent, Willowdale, Ont.*

**W. Perry,** Senior Inspector, Commercial Division, Northwest Industries Ltd., Box 517, Edmonton, Alta.: *11626 - 125th St., Edmonton, Alta.*

**H. Richter,** Production Planner, Trans-Canada Air Lines, Dorval, P.Q.: *5108 Balmoral Ave., Pierrefonds, P.Q.*

**R. A. Schaefer** (on transfer from Junior Member)

**PO M. Shah** (on transfer from Junior Member)

**W. G. Wells** (on transfer from Student)

*Junior Member*

**R. R. Baker** (on transfer from Student)

**R. H. Wheatley** (on transfer from Student)

*Student*

**L. M. Palacio,** McGill University: *Douglas Hall, 3851 University St., Montreal, P.Q.*

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*Associate*

**A. Marshall,** Canadian Representative, McDonnell Aircraft Corp., P.O. Box 516, St. Louis 66, Mo.: *141 Cooper St., Apt. 812, Ottawa 4, Ont.*

**G. McNaught,** Vice-President, Harrington Tool & Die Co. Ltd., 755 First Ave., Lachine, P.Q.

**D. T. Nicholson,** Pilot, Quebecair, Rimouski, P.Q.: *Apt. 409, 3220 Ridgewood, Montreal, P.Q.*

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## MEMBERSHIP OF THE C.A.I.

The qualifications and annual dues set out in the table below are those presently laid down by the By-laws. The rates of dues shown in brackets are those applicable to members resident outside Canada or the U.S.A.

The annual dues include a non-deductible subscription to the *Canadian Aeronautical Journal.*

An application form appears on the following two pages.

Additional forms may be procured from the Secretaries of the Branches or from C.A.I. Headquarters. An applicant does not apply for membership in any particular grade, but each application is considered by the Admissions Committee, who decide the grade suitable to the applicant's qualifications. On admission, the applicant is informed of his grading and the appropriate entrance fees and annual dues.

The entrance fee is $5.00, except in certain special circumstances.

| Grade | Summary of Qualifications | Annual Dues |
|---|---|---|
| Student | Undergoing a course of study at an approved school of engineering or technology | $3.00 ($2.00) |
| Junior Member | Engaged in technical work relating to aeronautics for not more than 4 years. | $5.00 ($2.00) |
| Technical Member | Engaged in technical work in aeronautics or related fields for 4 years or hold a recognized degree in mathematics, engineering or science. | $8.00 ($5.00) |
| Member | Engaged in technical work in aeronautics or related fields for 8 years and acquired a recognized standing | $10.00 ($6.00) |
| Associate | Engaged in work relating to aeronautics but not qualified for the technical grades. | $15.00 ($10.00) |
| Associate Fellow | Engaged in aeronautical science or engineering for 10 years and been in responsible charge or made outstanding contribution | $15.00 ($10.00) |
| Fellow | Been an Associate Fellow for 1 year and attained distinction in aeronautics | $15.00 ($10.00) |

CANADIAN AERONAUTICAL INSTITUTE

# APPLICATION FOR MEMBERSHIP

When completed, please forward to:

The Secretary,
Canadian Aeronautical Institute,
801 Commonwealth Building,
77 Metcalfe Street,
Ottawa 4, Ontario, Canada.

........................................
*Surname*

........................................
*Given Names*

........................................
*Dr., Mr., W/C etc.*
**Please complete the above in Capitals**

I hereby apply for membership in the Canadian Aeronautical Institute. I certify that all information I have given in this application is correct to the best of my knowledge, and that my references are personally familiar with my aeronautical qualifications.

If elected, I agree to abide by the By-laws and Regulations of the Canadian Aeronautical Institute. Upon termination of my membership, for any reason, I will not use the initials of the Institute after my name and will return, on request, any card, certificate, or insignia of membership.

Signature.................................................. Date..............................

**Office Record**

Date Recd.

Acknowlgd.

Code

Ref.

Elected

Grade

(Please type, or write legibly in ink)

Address for mail :
:
:

Telephone Nos.: Business:.................................... Residence:....................................

Permanent home address:....................................................................

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Date and place of birth:.................................................... Citizenship:........................

Business title, :
Firm name and :
address :

Firm's products, services:....................................................................

Your present duties:..........................................................................

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Service decorations, honorary awards, scholarships etc.........................................

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Date and No. of licence, certificate etc., if registered technician or pilot:......................

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Other aeronautical qualifications:............................................................

..............................................................................................

Current membership in other technical or professional organizations:

Entry Date　　Grade of Membership　　Organization

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Technical papers: Title, where presented or published:

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## ACADEMIC RECORD

| Dates | Name and Location of School | | Major Subject | Degree or Certificate |
|---|---|---|---|---|
| | Secondary Technical | | | |
| * | University Tech. Inst. | | | |
| | Other Courses | | | |
| | Additional Certificates or Degrees | | | |

*Students should indicate the date on which they expect to graduate.

## OCCUPATIONAL RECORD

**Give an explicit summary of your qualifying experience, beginning with current status, then previous positions. Use additional sheet if required.**

| Dates | Employer's Name, Address, Services | Specific Title, Grade or Position | Nature of Duties, Degree of Responsibility, Supervision Involved |
|---|---|---|---|
| | | | |

## REFERENCES

**Name at least four people (of which at least two must be members of the C.A.I., R.Ae.S., I.A.S. or E.I.C.) acquainted with your aeronautical background**

Name and Address

1. ..................................................

2. ..................................................

3. ..................................................

4. ..................................................

5. ..................................................

# Summer Employment

STUDENT members seeking summer jobs and Sustaining Member Companies offering employment during the summer are invited to get together through the Appointment Notices service of the Journal.

This service is offered free of charge to all members and Sustaining Members of the Institute (and, of course, is not confined to notices about summer employment). For publication in the March issue, members should send particulars of their qualifications and requirements to the Secretary before the 25th February. Notices will be published for two consecutive months and will thereafter be discontinued unless their reinstatement is specifically requested.

A Box No., to which enquiries may be addressed (c/o The Secretary), will be assigned to each notice submitted by an individual.

The Institute reserves the right to decline any notice considered unsuitable for this service or temporarily to withhold publication if circumstances so demand.